REMARKS

Applicant thanks the Examiner for an indication that claims 8, 10, 12-14, and 16-31 are allowed.

Claims 1-31 are currently pending in the application. By this amendment, claims 1, 9, 11, 15 and 18 are amended. No new matter is added. Reconsideration of the rejected claims in view of the above amendments and the following remarks is respectfully requested.

Claims 1, 9 and 18 were objected to. In response, claim 1 has been amended to recite "light emitting device array chips", claim 9 has been amended to delete the phrase "are each secured directly", and claim 18 has been amended to include the text "of the light-emmitting array chips having a light-emitting device". These amendments are substantially as suggested by the Examiner; thus, the objection should now be withdrawn.

Claims 11 and 15 were rejected under 35 U.S.C. §112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. Responding to this rejection, claims 11 and 15 were amended to avoid ambiguity of claim language. Applicant respectfully requests withdrawal of this rejection in a view of the present amendment.

Claims 1 and 9 were rejected under 35 U.S.C. §102(e) as being anticipated by Kondo et al (JP 2000-103116). This rejection is traversed.

First, JP 2000-103116 is not an issued U.S. Patent or published U.S. Patent application or an international application which designates the U.S. Therefore, it is not a reference under 35 U.S.C. 102 (e).

Second, JP 2000-103116 would not be a reference under any section of 35 U.S.C. 102 (e.g., a, b, e) since it does not demonstrate invention prior to the invention by the applicant. JP 2000-103116 to Kondo was published on April 11, 2000. The present application claims priority to four Japanese Application, the earliest of which has a priority date of April 6, 2000, which is prior to the publication date of the Kondo reference.

On January 19, 2001, the certified priority documents were submitted to the USPTO: JP 2000-104786 filed April 6, 2000; JP 2000-213005 filed July 13, 2000; JP 2000-213005 filed July 13, 2000; and JP 2000-310815 filed October 11, 2000. Attached to this amendment as

Attachment A are verified translations of each of the four above-referenced Japanese application (A declaration under 37 C.F.R. 1.55 accompanies the English language translations).

It is noted that all of the elements claimed in rejected claims 1 and 9 were presented in the Japanese Application filed April 6, 2000. Specifically, referring to Figure 1 of the Japanese Application JP 2000-104786 filed April 6, 2000 and to Claim 1 of the present specification:

Claim 1. An optical write head comprising a substrate (30), and a plurality of light emitting device array chips (32) arranged on the substrate (30) in a straight line or in a staggered layout so as to oppose a rod lens array (11), each of the light emitting device array chips (32) having a light emitting device array, wherein the rod lens array (11), a substrate support member (36) for supporting the substrate (30) and a drive circuit board (34) are each secured to a support member (40).

Analogously, referring to claim 9 and Figures 1 and 3 of Japanese Application JP 2000-104786 filed April 6, 2000:

Claim 9. A method of optically aligning elements of an optical write head comprising a substrate (30), and a plurality of light emitting device array chips (32) arranged on the substrate (30) in a straight line or in a staggered layout so as to oppose a rod lens array (11), each of the light emitting array device chips (32) having a light emitting device array, the method comprising the steps of securing the rod lens array by a plurality of adhesive injections (46), a substrate support member (40) for supporting the substrate (30), and a driver circuit board (34) to a support member (40), and die-bonding the light emitting device array chips (32) to the substrate (30) to a predetermined location on the substrate support member (40) while being positioned with respect to a reference plane of the substrate support member (40).

Additionally, the detailed description of the claimed apparatus is described on page 7, lines 14-25, page 8, lines 1-13, and page 9, lines 5-20 of the English language translation of Japanese Application JP 2000-104786 filed April 6, 2000. Further, the claimed method is described on

page 9, lines 1-25, of the English language translation of Japanese Application JP 2000-104786 filed April 6, 2000.

In view of the above and the documents of Attachment A, JP 2000-103116 to Kondo is not a reference against the claimed invention, and all rejections that have been made or could be made based on this reference should now be withdrawn.

In view of the foregoing amendments and remarks, Applicant submits that all of the claims are patentably distinct from the prior art of record and are in condition for allowance. The Examiner is respectfully requested to pass the above application to issue. The Examiner is invited to contact the undersigned at the telephone number listed below, if needed. Applicant hereby makes a written conditional petition for extension of time, if required. Please charge any deficiencies in fees and credit any overpayment of fees to Attorney's Deposit Account No. 50-2041 (Whitham, Curtis & Christofferson, P.C.).

Respectfully submitted,

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ATTACHMENT A

VERIFIED TRANSLATIONS OF JAPANESE APPLICATIONS

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re patent application of Masahide Washikawa

Docket No. N36-131337M/AIO

Serial No.: 09/825,889

Group Art Unit: No.2861

Filed: April 5, 2001

Examiner: Pham, Hai Chi

For: OPTICAL WRITE HEAD, AND METHOD OF ASSEMBLING THE SAME

DECLARATION UNDER 37 CFR 1.55(a)

(Pursuant to 37 CFR 1.68)

Honorable Commissioner of Patents and Trademarks
Alexandria, VA 22313-1450

Sir:

I, Atsushi INOUE, declare and state:

that I am a citizen of Japan, having an Office at P.O. Box 521, ARK Mori Building 13F, 12-32, Akasaka 1-chome, Minato-ku, Tokyo, 107-6013 JAPAN;

that I well understand the Japanese and English languages;

that the attached English-language document is full, true and faithful translation made by me of Japanese Application No. 2000-104786 filed on April 6, 2000, 2000-213005 filed on July 13, 2000, 2000-213006 file on July 13, 2000 and 2000-310815 filed on October 11, 2000 on which the right of priority under the International Convention is claimed for the above-identified application.

I declare further that all statements made herein of my own knowledge are true that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful statements may jeopardize the validity of the Application or any patent issuing thereon.

Date: January 8, 2004

Atsushi Inoue

Atsushi INOUE

PATENT OFFICE
JAPANESE GOVERNMENT

This is to certify that the annexed is a true copy of the following application as filed with this office.

Date of Application: April 6, 2000

Application Number: Patent Application No.2000-104786

Applicant(s): NIPPON SHEET GLASS CO., LTD.

May 25, 2001

Commissioner,
Patent Office

Kozo OIKAWA (Seal)

Issuance No. 2001-3043249

[DOCUMENT NAME] Patent Application

[REFERENCE NUMBER] 00P126

[ADDRESSEE] Commissioner, Patent Office, Esq.

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[PATENT ATTORNEY]

[NAME OR APPELLATION] Seiichi OONO

[INDICATION OF PAYMENT]

[DEPOSIT ACCOUNT BOOK NUMBER] 012298

[AMOUNT OF PAYMENT] 21000

[LIST OF FILED DOCUMENT]

[DOCUMENT NAME] Specification 1

[DOCUMENT NAME] Drawing 1

[DOCUMENT NAME] Abstract 1

[GENERAL POWER OF ATTORNEY NO.] 9706787

[REQUEST FOR PROOF] Yes

[Document Name] Specification

[Title of the Invention] Optical Write Head and Method of Assembling the same

[Claims]

[Claim 1] An optical write head comprising a substrate, and a plurality of light-emitting element array chips arranged on the substrate in a straight line or in a staggered layout so as to oppose a gradient index rod lens array, each of the light-emitting array chips having a light-emitting element array, wherein the rod lens array, a substrate support member for supporting the substrate, and a driver circuit board are fixedly held by a support member.

[Claim 2] The optical write head according to claim 1, wherein the support member and the substrate support member are formed from metallic material.

[Claim 3] The optical write head according to claim 1 or 2, wherein at least one of side plates of the rod lens array to be bonded to a support member is a glass plate.

[Claim 4] The optical write head according to any one of claims 1 to 3, wherein a plurality of adhesive injection holes are formed in a surface of the support member with which the rod lens array is to be brought into contact, the holes being arranged along a longitudinal direction of the rod lens array and being formed so as to penetrate through the support member

to a reverse side thereof.

[Claim 5] The optical write head according to any one of claims 1 to 3, wherein at least one slit of V-shaped cross section for injecting an adhesive is formed in a portion of the surface of the support member to be brought into contact with the rod lens array, so as to extend in the longitudinal direction of the rod lens array, and a plurality of adhesive injection holes are formed in the slit so as to penetrate through the support member to a reverse side thereof.

[Claim 6] The optical write head according to claim 1, wherein at least two positioning pins are provided at predetermined positions on the support member.

[Claim 7] The optical write head according to claim 1, wherein at least two rotatable eccentric pins penetrating through the support member are provided so as to come into contact with the substrate support member.

[Claim 8] A method of assembling the optical write head according to claim 1, wherein the at least two eccentric pins are rotated, to thereby move the substrate support member kept in contact with the eccentric pins and adjust the distance between a light-emission section of the light-emitting element array and a light-incident end face of the rod lens array.

[Claim 9] A method of assembling the optical write head according to claim 1, wherein the light-emitting element array chips are die-bonded to the substrate bonded to a predetermined

location on the substrate support member while being positioned with respect to a reference plane of the substrate support member.

[Detailed Description of the Invention]

[Field of the Invention]

The present invention relates to the structure of an optical write head using light-emitting element arrays and to be provided in a high-resolution electrophotographic printer, and to an optical axis position adjusting method.

[Related Art]

An optical write head to be used in an optical printer has hitherto been equipped with light-emitting element arrays, such as light-emitting diodes. The principle of an optical printer equipped with an optical write head is illustrated in Fig. 3. The surface of a cylindrical photosensitive drum 2 is coated with material (photosensitive material) possessing optical conductivity, such as amorphous Si or organic material. The photosensitive drum 2 rotates in accordance with a print speed. To begin with printing, the surface of photosensitive material provided over a rotating drum is charged uniformly with an electrostatic charger 4.

Next, an optical write head 6 radiates, onto the photosensitive material, light which assumes the image of a dot to be printed, thereby neutralizing the thus-exposed portion of the photosensitive material and forming a latent image. Subsequently, a development unit 8 causes toner to adhere to

the photosensitive material in accordance with the charged status of the photosensitive material. A transfer unit 10 transfers toner onto paper 14 supplied from a cassette 12. A fixing unit 16 applies heat to the paper, thereby fixing the toner transferred on the paper. The paper is then fed to a stacker 18. After transfer of the latent image has been completed, the entirety of the electrically-charged photosensitive drum 2 is neutralized by an erasure lamp 20, and residual toner is removed by a cleaner unit 22.

The optical write head which has hitherto been employed is constructed such that a plurality of light-emitting element array chips are arranged in a single line or in a staggered layout on a substrate, in accordance with specifications pertaining to a print width and such that a rod-lens array or rod-lens arrays (e.g., product name: SELFOC Lens array manufactured by Nippon Sheet Glass Co. Ltd.) having gradient index rod lenses stacked thereon in the form of one or two lines is arranged opposite the light-emitting element array chips. Fig. 6 is a perspective view showing a rod lens array 11 having rod lenses stacked in two rows. A plurality of gradient index rod lenses 24 are sandwiched between side plates 26 and secured by means of resin 28.

In association with an increase in print speed and an improvement in resolution, required precision of alignment of an optical system is increased significantly. A geometrical layout of related-art mechanical components fails to maintain

the precision of the mechanical components, to thereby fail to satisfy performance requirements of the optical system.

Obtaining a high-resolution image requires setting within a range of $\pm 30\mu m$ respective specified values of the amount of deviation between the center of an optical axis and an illumination point of each of light-emitting elements, the distance from the illumination point to the end face of a rod lens array, and the distance from a photosensitive surface to the end face of the rod lens array.

(1) The lengths of rod lenses have a variation of about ± 0.4 mm in manufacture. (2) There may be a case where the rod lens array has warpage toward an image surface or an object surface. (3) Fiber-reinforced plastics (FRP) from which a side plate of the rod lens array is formed has a variation of about $\pm$ 0.4 mm in thickness. Even if an optical component is positioned along the mechanical components, the precision of positioning exceeds a required range of optical precision, thereby failing to satisfying optical performance.

For this reason, there has arisen a necessity of three-dimensionally aligning the position of the rod lens array to a light-emitting element array. More specifically, (1) the distance between an illumination point and the surface of a photosensitive material must be matched with a conjugate length of the rod lens array; (2) the longitudinal center of a lens

belonging to the rod lens array must be set to the center of the distance; and (3) deviation between the optical axis of the rod lens array, an illumination point, and the position of the surface of a photosensitive material must be adjusted with respect to the longitudinal direction of the rod lens array.

For this reason, a space is ensured beforehand between the housing of the optical write head and the rod lens array. The rod lens array is three-dimensionally aligned. The rod lens array is secured on the housing of the optical write head by means of filling the space with a silicon-based adhesive.

[Problems to be solved by the Invention]

However, in order to align the optical axis of the rod lens array in the longitudinal direction thereof, the alignment must be performed through use of an actuator having high positional precision. An enormous amount of alignment time is required.

The mechanical components must be formed into complicate shapes, by means of ensuring, for example, a space for effecting alignment of an optical axis. Such complicated working of the mechanical components is a contributory factor to hindering a reduction in manufacturing costs of an optical write head.

In most cases, a head housing of the related-art optical write head is molded from engineering plastics. In a case where a rod lens array having the optical axis aligned is secured to the head housing, a silicon-based adhesive is usually used. Heat contraction (a contraction of about 8% arises in volume

of the adhesive), which arises after the adhesive has been filled and cured, or distortion of material of the head housing, which is caused by contraction of the head housing with time, poses difficulty in guaranteeing the positional precision of the optical axis over a period of years.

The present invention has been conceived to solve the drawbacks set forth and is aimed at providing an optical write head which obviates a necessity of alignment operation by use of a high-precision device and a necessity of complicated mechanical components, enables lower-cost manufacture of the optical write head, and is less susceptible to time-varying changes.

[Means for solving the problems]

To solve the problems, according to the present invention, there is provided an optical write head comprising a substrate, and a plurality of light-emitting element array chips arranged on the substrate in a straight line or in a staggered layout so as to oppose a gradient index rod lens array, each of the light-emitting array chips having a light-emitting element array, wherein the rod lens array, a substrate support member for supporting the substrate, and a driver circuit board are fixedly held by a support member.

Preferably, the support member and the substrate support member are formed from metallic material. Further, at least one of side plates of the rod lens array to be bonded to a support

member is preferably a glass plate.

Preferably, a plurality of adhesive injection holes are formed in a surface of the support member to which the rod lens array is to be brought into contact, arranged in a longitudinal direction of the rod lens array and formed so as to penetrate through the support member to a reverse side thereof. Alternatively, at least one slit of V-shaped cross section for injecting an adhesive is preferably formed in a portion of the surface of the support member to be brought into contact with the rod lens array, so as to extend in the longitudinal direction of the rod lens array, and a plurality of adhesive injection holes are formed in the slit so as to penetrate through the support member to a reverse side thereof.

Preferably, at least two positioning pins are provided at predetermined positions on the support member so as to come into contact with the substrate or the substrate support member. Alternatively, at least two eccentric pins capable of penetrating through the support member and rotating are preferably provided so as to come into contact with the substrate support member.

Preferably, the two eccentric pins are rotated, to thereby move the substrate support member remaining in contact with the eccentric pins and to adjust the distance between a light-emission section of the light-emitting element array and a light-incident end face of the rod lens array. Further, light-emitting array chips are preferably die-bonded to a substrate bonded to

predetermined locations on the substrate support member while the position of the substrate is taken as a reference plane of the substrate support member.

[Embodiment of the Invention]

Fig. 1 is a cross-sectional view showing the structure of an optical write head according to the present invention. Fig. 2 is a schematic perspective view of the structure when viewed from the front. Fig. 3 is a schematic perspective view of a portion of the structure when viewed from the reverse side. An example structure of the optical write head which maintains the precision of an optical axis will now be described by reference to these drawings.

Light-emitting element array chips 32 are mounted on a substrate 30. A light-emitting element array illuminates in response to an electric signal output from a driver circuit board 34. The light forms an image on a photosensitive drum 2 by way of a rod lens array 11. The substrate 30 is bonded to a substrate support member 36. As shown in Fig. 1, the rod lens array 11, the substrate support member 36, and the driver circuit board 34 are bonded to a reference plane A of a support member 40.

First, there will be described a method of positioning the center of an optical axis.

A reference plane A of the support member 10 is a precision-machined plane. The rod lens array 11 is positioned in the thicknesswise direction thereof, by means of bringing

a side plate 26 of the rod lens array 11 close contact with the reference plane A. However, FRP is usually employed for the side plate 26 of the rod lens array 11, and the side plate 26 has a thickness precision of about ±0.4 mm. Such thickness precision accounts for occurrence of variations in distance from the outer surface of the side plate to the center of the of the rod lens. In addition, orientation of glass fibers of FRP results in irregularities arising in the surface of FRP. Even at the time of manufacture of a rod lens array, the row of rod lenses is disarranged when rod lenses are arranged on an FRP plate.

In order to prevent occurrence of disarrangement, a low-cost glass plate having superior thickness precision is used as the side plate 26. As a result, the precision of distance between the center of an optical axis 42 of the rod lens and the outer surface of the side plate can be improved so as to fall within a range of ±15 μm. Further, disarrangement of rod lenses can also be eliminated. Ordinary soda lime glass cut to a predetermined size can be used as a glass plate. Hence, the glass plate is inexpensive.

In a case where the rod lens array 11 is bonded to the support member 40, the precision of thickness of an adhesive cannot be guaranteed. In order to guarantee the thickness precision, there has been conceived a method of bonding the rod lens array 11 to the support member 40 without being sensitive to the precision of thickness of an adhesive.

As shown in Fig. 3, at least one slit 44 having a V-shaped cross section is formed in the surface of the support member 40 which is to come into contact with the side plate 26 of the rod lens array 11, so as to extend in the longitudinal direction of the rod lens array 11. A plurality of adhesive injection holes 46 are formed at appropriate intervals in the slit 44 so as to penetrate the support member 40 to the reverse side thereof.

In a case where warpage arises in the rod lens array itself, the support member 40 and the rod lens array 11 are positioned while longitudinal warpage and lateral warpage in the rod lens array 111 are corrected, thereby pressing the rod lens array 11 against the support member 40 under an appropriate load. For instance, an instantaneous adhesive of low viscosity is poured onto the surface of the support member 40 which is to come into contact with the side plate 26 of the rod lens array 11, by way of the adhesive injection holes 46. The adhesive can spread over an adhesion surface across the entire length of the rod lens array 11 by way of the slit 44 and by means of capillary action.

Alternatively, an epoxy-based adhesive of low viscosity is poured into the adhesive injection holes 46. The rod lens array 11 may be bonded by means of only an adhesive poured into dot shapes at a plurality of points corresponding to the adhesive injection holes 46. In this case, the slit 44 is obviated, and the only requirement is that a plurality of adhesive injection

holes 46 be formed at appropriate intervals in the surface of the support member 40 which is to come into contact with the side plate 26 of the rod lens array 11, in the longitudinal direction of the rod lens array 11 so as to penetrate the support member 140 to the reverse side thereof.

According to the method, the adhesive does not enter a gap between the surface of the rod lens array 11 and the surface of the support member 40, thereby preventing occurrence of variations in precision of thickness of the adhesive.

In consideration of ease of precision working of the surface of the support member 40, the influence of temperature and physical shock on the precision of the support member 40, and time-varying changes in the material of the support member 40 due to residual stress of the material, metallic material is preferably selected for the support member 40. Even in this regard, forming the side plate 26 of the rod lens array 111 from glass material whose coefficient of thermal expansion is closer to that of metal than to that of FRP is effective for preventing exfoliation of the rod lens array 11 from the support member 40, which would otherwise be caused by temperature changes.

There will now be described a method of positioning the light-emitting element array chips 32. When the light-emitting element array chips 32 are die-bonded to the substrate 30, die-bonding is effected while a pattern of given geometry printed on the substrate 30 is recognized as an image. In this case,

when the substrate 30 is mounted on an optical write head, there is no alternative but to take the end face of the substrate 30 as a reference plane.

The precision of distance between the end face of the substrate 30 and illumination points of the light-emitting element array chips 32 and parallelism between the substrate 30 and the illumination points are not ensured during manufacturing processes. Aligning the light-emitting element array chips 32 to the optical axis 42 of the rod lens array 11 by means of laying out a mechanism is impossible.

In order to make alignment feasible, the substrate 130 is bonded to the support member 36 or secured to the same by means of another method before the light-emitting element array chips 32 are mounted on the substrate 30. Next, the light-emitting element array chips 32 are die-bonded onto the substrate 30, by means of taking a precision-machined reference plane B of the substrate support member 36 as a reference. Subsequently, the reference plane A of the support member 40 and the reference plane B of the substrate support member 36 are fixed together by means of butt-joining. The precision of distance Y between the reference plane A of the support member 40 and the illumination point depends only on the precision of a die bonder, and a range of ± 10 μm is ensured for the distance Y between the reference plane A and the illumination point. The substrate support member 36 is secured to the support member 40 by means of forming through

holes 38 in the substrate support member 36, forming tapped holes 48 at positions corresponding to the support member 40, and tightly screwing bolts 50 into the tapped holes 48. The diameter of the through holes 38 is made larger than that of the bolts 50, thereby enabling positional adjustment to be described later. Thus, the amount of offset between the optical axis of the rod lens array 11 and the optical axis of the light-emitting element array 32 can be reduced to a range of ±25 μm by means of the precision of assembly of the mechanical components.

There will now be described a method of positioning the rod lens array 11 in a direction of optical axis operating range LO. As mentioned previously, longitudinal warpage and lateral warpage in the rod lens array 11 are corrected by a jig when the rod lens array 11 is bonded to the support member 40. Further, the warpage is eliminated by use of glass material for the side plate 26 of the rod lens array 11. However, variations due to manufacture exist in an operating range TC and the lens length Z. LO has variations falling within a range of ±0.15 mm, and the operating range TC has variations falling within a range of ±0.3 mm. The distance between the rod lens array 11 and illumination points must be set to the operating range of the rod lens array 11, as the occasion requires.

Since the lens operating lens is predetermined, means for adjusting the distance between the rod lens array 11 and the

light-emitting elements is required. Two eccentric pins 58 to penetrate through the support member 40 are attached as the adjustment means in the longitudinal direction (see Fig. 2). The eccentric pins 58 rotate eccentrically with respect to eccentric pin housings 59. The eccentric pin housings 59 are secured to predetermined positions on the support member 40, and the tip ends of the eccentric pins 58 are positioned so as to come into contact with the substrate support member 36. The position of the substrate support member 36 is adjusted by means of rotating the two eccentric pints 58 such that the operating ranges TC and LO become specified operating ranges. At the time of adjustment, the bolts 50 are unfastened, and the substrate support member 36 can slide over the support member 40. After positioning, the substrate support member 36 is fastened.

A method shown in Fig. 4 may be employed as a method of positioning the rod lens array 11 in a direction of optical axis operating range LO. The support member 40 is held at a fixed position on a head housing 60. Two through holes 52 are formed at positions between the rod lens array 11 of the support member 40 and the substrate support member 36 in the longitudinal direction. Two positioning pins 56 set at positions of specified values beforehand are inserted into the through holes 52 until the pins 56 protrude from the surface of the support member 40. The diameter of the through holes 52 is made larger than that of the positioning pins 56, thereby preventing the positioning pins 56 from coming

into contact with the interior surfaces of the through holes 52. While the positioning pins 56 are taken as reference pins, the substrate support member 36 is fastened so as to come into contact with the positioning pins 56. As a result, an appropriate range LO can be ensured in accordance with variations in operating range.

The driver circuit board 34 is secured to the support member 40. As a result, wires to be provided between the substrate 30 having the light-emitting element array chips 32 mounted thereon and driver circuits can be shortened, thus diminishing influence of noise and miniaturizing the optical write head.

[Effect of the Invention]

The optical write head according to the present invention enables high-resolution and easy alignment of the optical axis of the rod lens array to illumination points of the light-emitting elements while the surface of the support member is taken as a reference plane. Further, the operating range of the optical axis of the rod lens array can also be adjusted easily. The positional precision of the rod lens array can be sustained stably over time. Hence, there can be embodied a low-cost optical write head which enables writing of a high-resolution image.

[Brief Description of the Drawings]

Fig. 1 is a cross-sectional view showing an optical write head according to an embodiment of the present invention;

Fig. 2 is a front perspective view showing the optical write

head according to the embodiment;

Fig. 3 is a back perspective view showing the optical write head according to the embodiment;

Fig. 4 is a cross-sectional view showing an optical write head according to another embodiment of the present invention;

Fig. 5 is a schematic view showing the principle of an optical printer equipped with an optical write head; and

Fig. 6 is an illustration showing the structure of a gradient index rod lens array.

[Description of Reference Numerals]

2 photosensitive drum
6 optical write head
11 rod lens array
26 side plate
32 Light-emitting element array chip
34 drive circuit board
36 substrate support member
40 support member
42 optical axis
44 slit
50 bolt
56 positioning pin
58 eccentric pin
60 head housing

[Document Name] Abstract

[Abstract]

[Object]

To provide an optical write head which obviates a necessity of alignment operation by use of a high-precision device and a necessity of complicated mechanical components, enables lower-cost manufacture of the optical write head, and is less susceptible to time-varying changes.

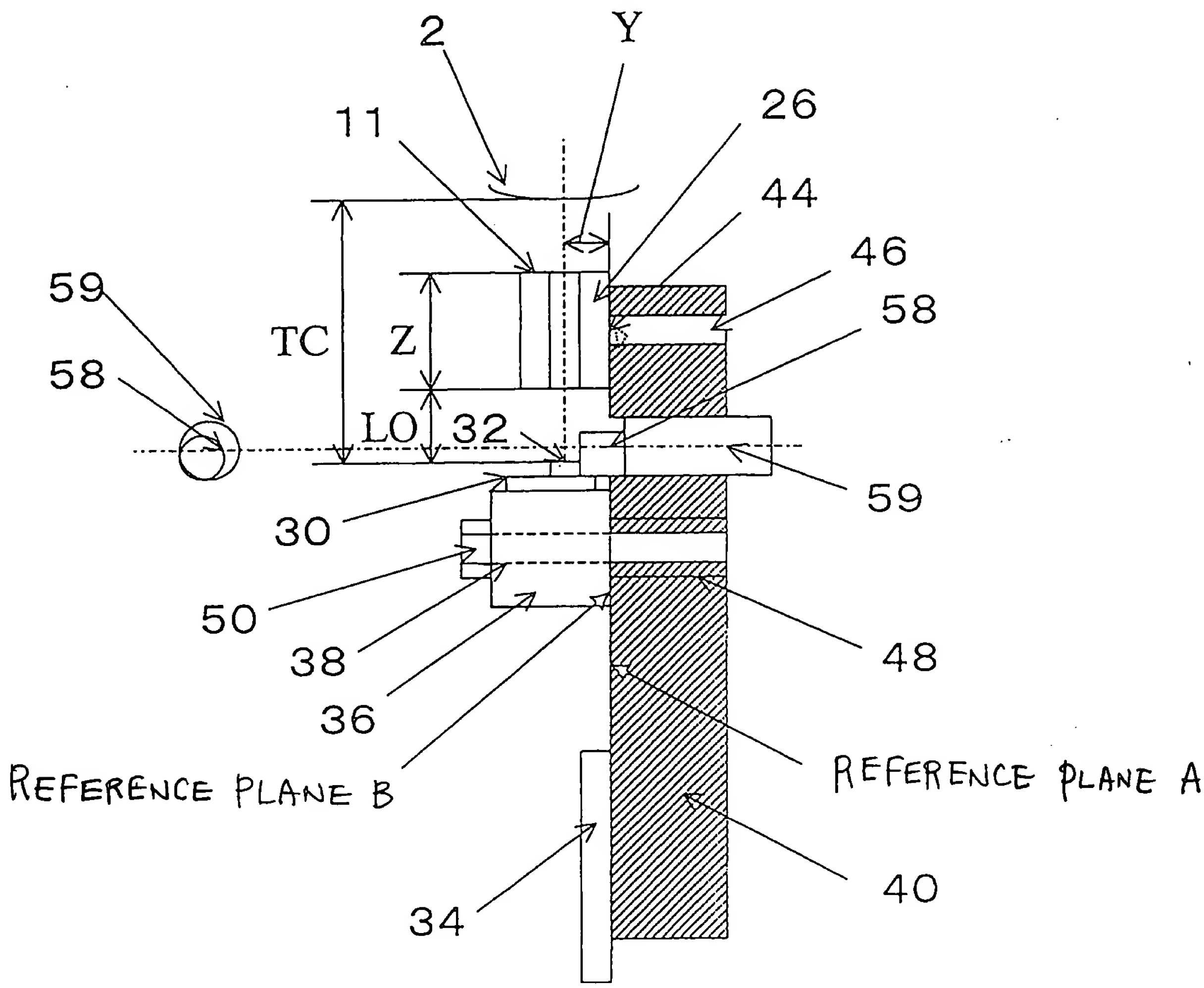
[Solving means]

A rod lens array 11, a substrate support member 36 for supporting a substrate 30, and a driver circuit board 34 are fixedly held by a support member 40. The support member 40 and the substrate support member 36 are formed from metallic material, and a side plate 26 of the rod lens array 11 is formed from a glass plate. Further, distance between a light-emitting section of a light-emitting element array and a light-incident end face of the rod lens array 11 is adjusted, by means of rotating eccentric pins 58. Further, light-emitting element array chips 32 are die-bonded on the substrate 30 bonded at predetermined positions on the substrate support member 36 while the position of the substrate support member 36 is taken as a reference plane.

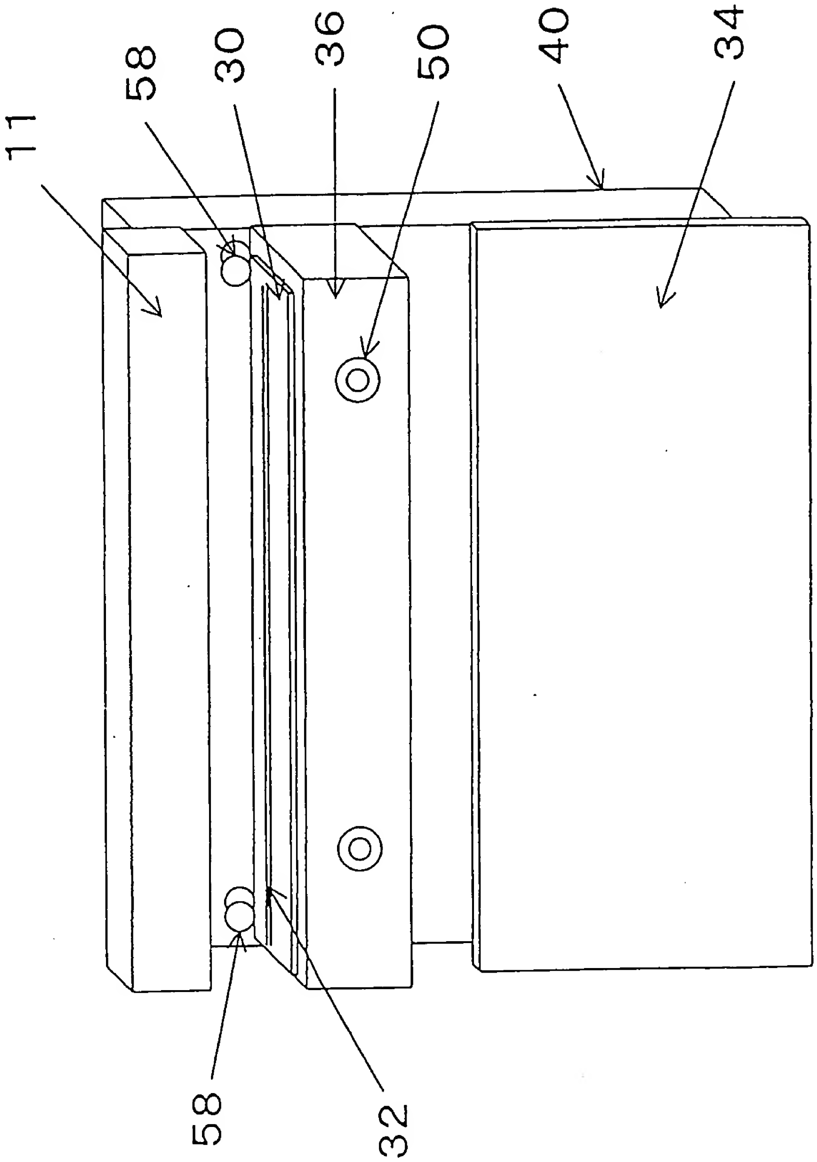
[Selected Drawing] Fig. 1

[Name of Document] Drawings

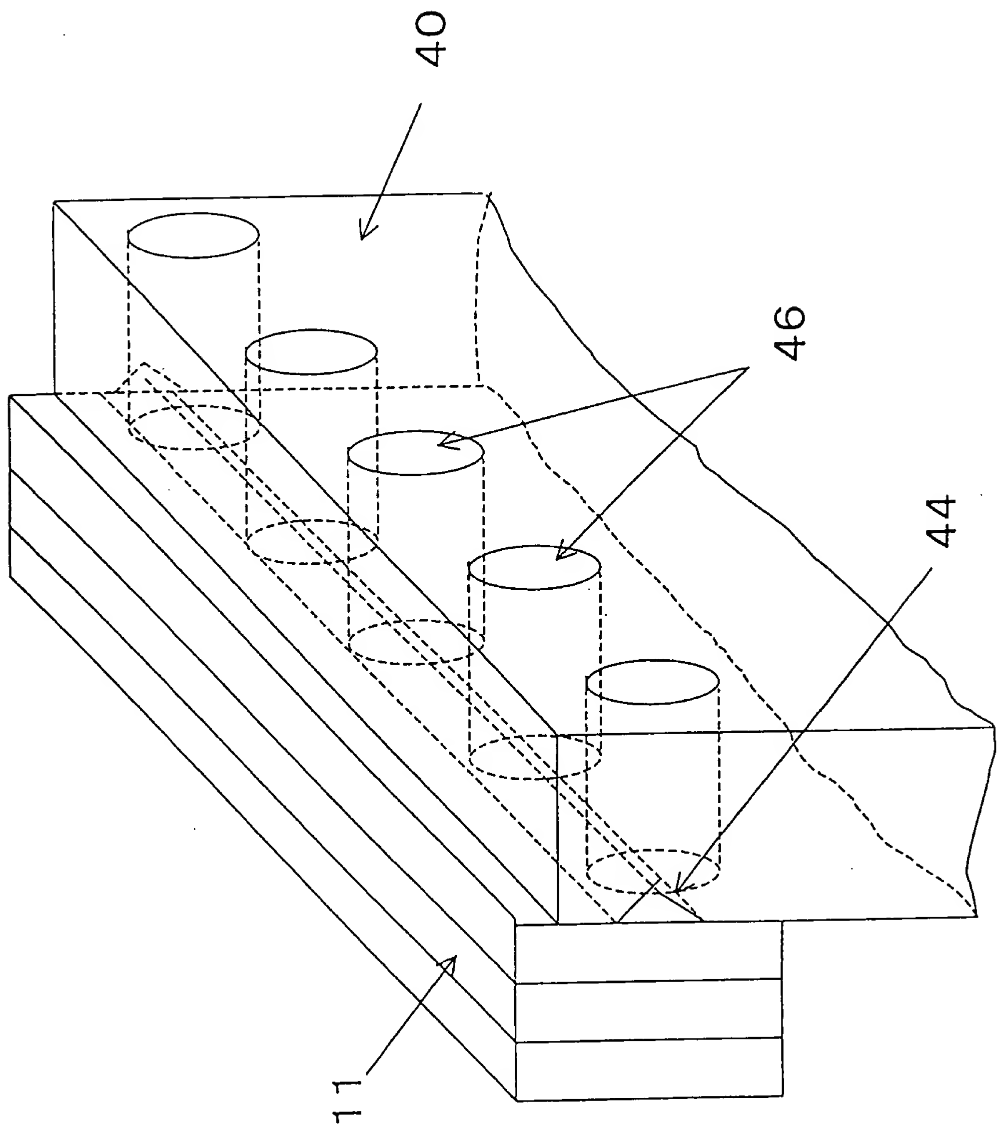
[Fig. 1]



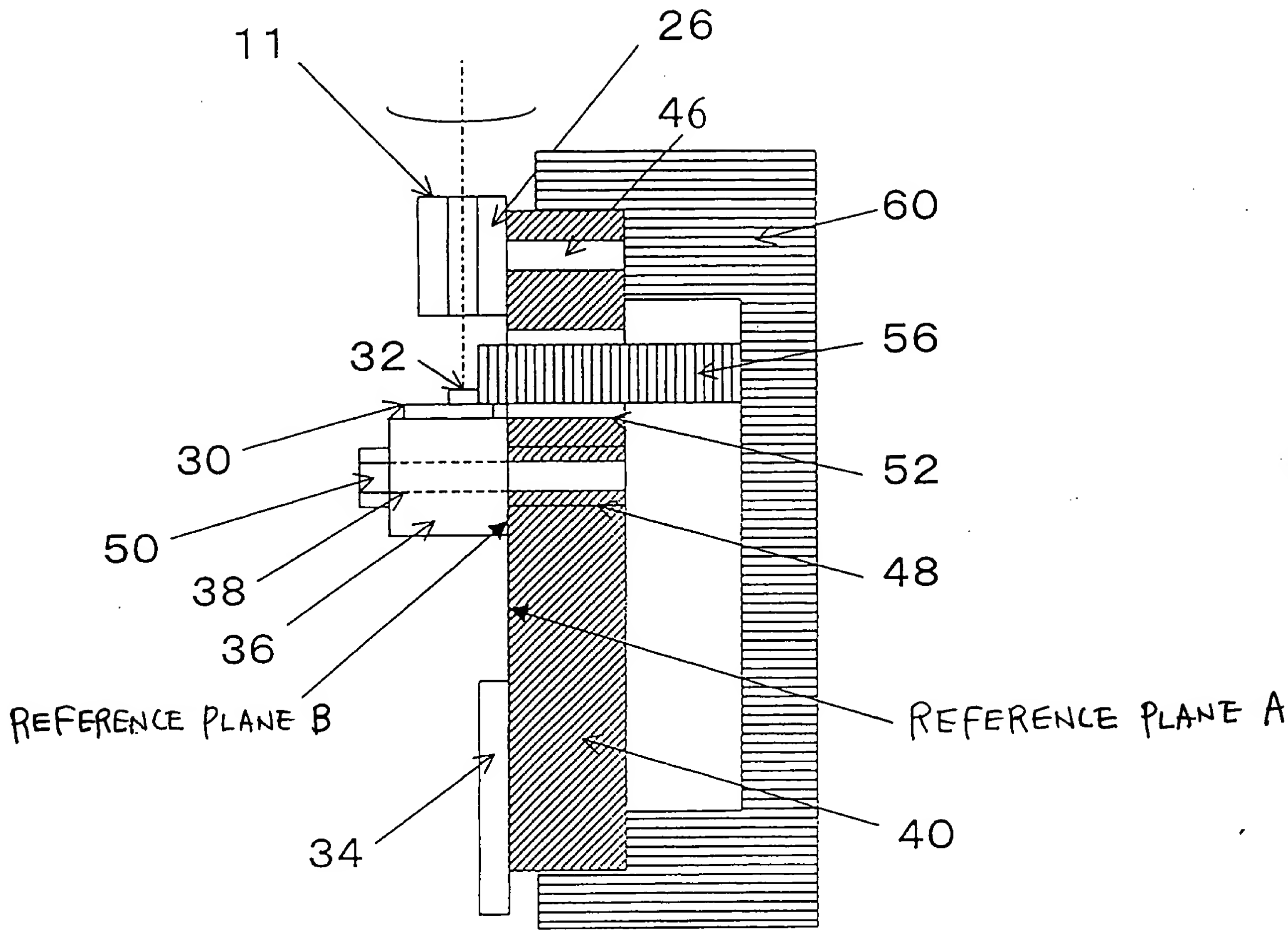
[Fig 2]



[Fig.3]



[Fig. 4]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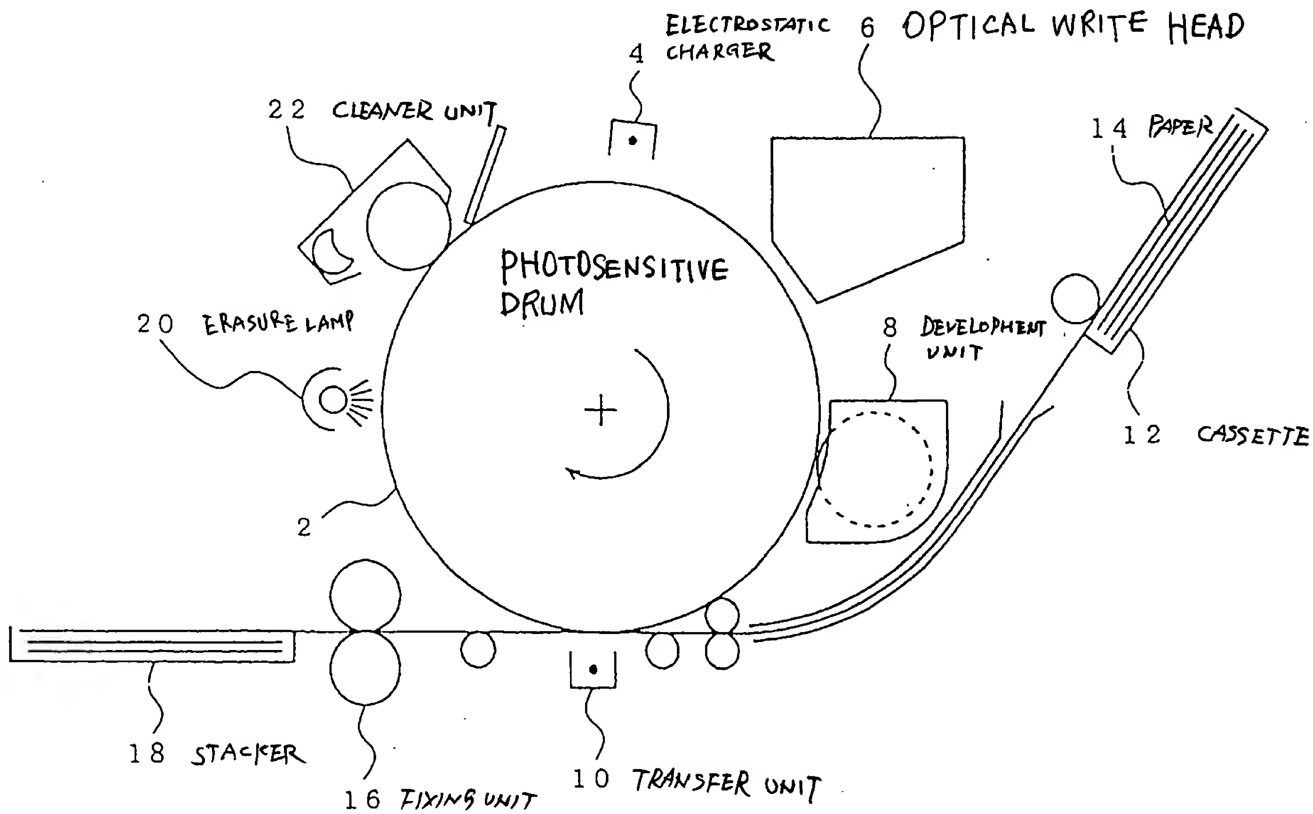
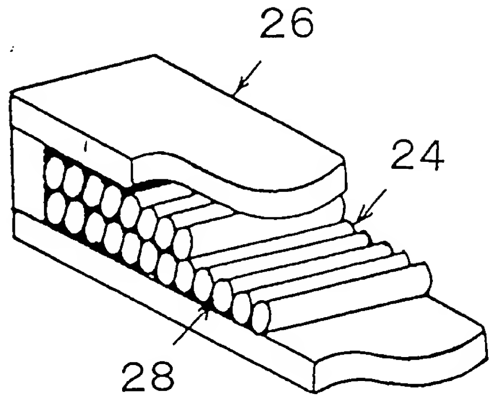
50
38
48
36
REFERENCE PLANE B
REFERENCE PLANE A
40
34

[Fig. 5]



2
PHOTOSENSITIVE DRUM
4 ELECTROSTATIC CHARGER
6 OPTICAL WRITE HEAD
8 DEVELOPMENT UNIT
10 TRANSFER UNIT
12 CASSETTE
14 PAPER
16 FIXING UNIT
18 STACKER
20 ERASURE LAMP
22 CLEANER UNIT

[Fig.6]



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This is to certify that the annexed is a true copy of the following application as filed with this office.

Date of Application: October 11, 2000

Application Number: Patent Application No.2000-310815

Applicant(s): NIPPON SHEET GLASS CO., LTD.

May 25, 2001

Commissioner,
Patent Office

Kozo OIKAWA (Seal)

Issuance No. 2001-3043304

[DOCUMENT NAME] Patent Application

[REFERENCE NUMBER] 00P386

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[CLAIMING A DOMESTIC PRIORITY BASED ON THE PREVIOUS APPLICATION]

[APPLICATION NO.] Patent Application No.2000-213006

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[DEPOSIT ACCOUNT BOOK NUMBER] 012298

[AMOUNT OF PAYMENT] 21000

[LIST OF FILED DOCUMENT]

[DOCUMENT NAME] Specification 1

[DOCUMENT NAME] Drawing 1

[DOCUMENT NAME] Abstract 1

[GENERAL POWER OF ATTORNEY NO.] 9706787

[REQUEST FOR PROOF] Yes

[Document Name] Specification

[Title of the Invention] Optical Write Head

[Claims]

[Claim 1] An optical write head comprising a flexible circuit board remaining in close contact with a member having rigidity, and a plurality of light-emitting element array chips arranged on the flexible circuit board in a straight line or in a staggered layout so as to oppose a gradient index rod lens array, each of the light-emitting array chips having a light-emitting element array, wherein the member having rigidity is a metallic member substantially equal in coefficient of thermal expansion to the rod lens array.

[Claim 2] An optical write head comprising a flexible circuit board remaining in close contact with a member having rigidity, and a plurality of light-emitting element array chips arranged on the flexible circuit board in a straight line or in a staggered layout so as to oppose a gradient index rod lens array, each of the light-emitting array chips having a light-emitting element array, wherein the member having rigidity is a metallic member substantially equal in coefficient of thermal expansion to the light-emitting element array chips.

[Claim 3] The optical write head according to claim 1 or 2, wherein a side plate of the rod lens array is formed from glass, and the metallic member is a nickel alloy or titanium.

[redacted]

[Claim 4] The optical write head according to any one of claims 1 to 3, wherein the light-emitting element array is a self-scan-type light-emitting element array.

[Detailed Description of the Invention]

[Field of the Invention]

The present invention relates to an optical write head used, for instance, in an electrophotographic printer, using light-emitting element array chips.

[Related Art]

An optical write head to be used in an optical printer has hitherto been equipped with light-emitting element arrays, such as light-emitting diodes. The principle of an optical printer equipped with an optical write head (an optical printer head) is illustrated in Fig. 5. The surface of a cylindrical photosensitive drum 2 is coated with material (photosensitive material) possessing optical conductivity, such as amorphous Si or organic material. The photosensitive drum 2 rotates in accordance with a print speed. To begin with printing, the surface of photosensitive material provided over a rotating drum is charged uniformly with an electrostatic charger 4.

Next, an optical write head 6 radiates, onto the photosensitive material, light which assumes the image of a dot to be printed, thereby neutralizing the thus-exposed portion of the photosensitive material and forming a latent image. Subsequently, a development unit 8 causes toner to adhere to

the photosensitive material in accordance with the charged status of the photosensitive material. A transfer unit 10 transfers toner onto paper 14 supplied from a cassette 12. A fixing unit 16 applies heat to the paper, thereby fixing the toner transferred on the paper. The paper is then fed to a stacker 18. After transfer of the latent image has been completed, the entirety of the electrically-charged photosensitive drum 2 is neutralized by an erasure lamp 20, and residual toner is removed by a cleaner unit 22.

As shown in a cross-sectional view of Fig. 6, in the optical write head 6, a plurality of light-emitting element array chips 30 are arranged in a single line on a printed circuit board 32 formed from glass epoxy, in accordance with specifications pertaining to a print width. A rod-lens array 34 having gradient index rod lenses stacked thereon in the form of one or two lines is arranged opposite the light-emitting element array chips 30. The light-emitting element array chips 30 and the rod lens arrays 34 are fixed on a housing 36 by means of a silicon filler 38.

A light-emitting diode (LED) array has usually been used widely as a light-emitting element array. Each of the LED elements involves variations in the amount of light emission. Further, each of rod lenses involves variations in optical characteristic. These variations account for inconsistencies in density of an image. If a currently-available LED array is used in its present form, variations in density will exceed the allowable density

limit of the LED. For this reason, the amount of light is corrected such that inconsistencies in density of an image fall within the allowable density limit of an LED, by means of changing drive conditions for each of LEDs. The amount of light is usually corrected in accordance with the following procedures. While the optical write head is separated from the printer, LEDs are illuminated one by one, and a light-receiving element is situated at a position where an image is to be formed, thereby determining the distribution of light quantity over the head in its longitudinal direction. The thus-determined distribution of light quantity is recorded. A per-chip drive current to be supplied to LEDs or the period of illumination of the respective chip of LEDs is determined from the recorded light quantity distribution such that the light quantity distribution is flattened. At the time of actual use of the light-emitting array, the thus-determined drive conditions are employed.

[Problems to be solved by the Invention]

However, in practice, an optical write head is assembled or used in the environment where ambient temperature changes. The positional precision of layout of light-emitting element array chips is influenced by thermal expansion of a glass epoxy substrate. Further, the positional precision of layout of a rod lens array is influenced by thermal expansion of glass-fiber-reinforced plastic (GFRP). Accordingly, there may be a case where the optical axis of a light-emitting array chip

and the optical axis of a rod lens may deviate from an initially-adjusted position in the longitudinal direction of the print head. Inconsistencies in an image stemming from such deviation cannot be compensated by the electrical correction of light quantity set forth.

Even in a process of die-bonding light-emitting element array chips to a substrate, heating is required for setting a conductive adhesive. In the course of a cooling operation for setting the thus-heated adhesive, residual stress develops between the chip and the substrate. The residual stress induces distortion in the substrate, thereby deteriorating the positional precision of the chip. Even a pitch between the chips encounters the same problem.

The present invention is aimed at solving the foregoing drawback, providing an optical write head having high reliability with respect to temperature variations, and realizing a high-resolution electrophotographic printer.

[Means for solving the problems]

There is provided an optical write head comprising a flexible circuit board remaining in close contact with a member having rigidity, and a plurality of light-emitting element array chips arranged on the flexible circuit board in a straight line or in a staggered layout so as to oppose a gradient index rod lens array, each of the light-emitting array chips having a light-emitting element array, wherein the member having rigidity

is a metallic member substantially equal in coefficient of thermal expansion to the rod lens array. Preferably, the member having rigidity is a metallic member substantially equal in coefficient of thermal expansion to the light-emitting element array chips.

Preferably, a side plate of the rod lens array is formed from glass, and the metallic member is a nickel alloy or titanium. Further, in a case where the light-emitting element array chips are formed from GaAs-based semiconductor, the member having rigidity can be made substantially equal in coefficient of thermal expansion to the light-emitting element array chips, as a result of use of the metallic material. Preferably, a self-scan-type light-emitting element array is used for the light-emitting element array.

[Embodiment of the Invention]

An embodiment of the present invention will be described hereinbelow by reference to Figs. 1 through 3. Fig. 1 is a side view showing the side of an optical write head according to the present invention, the side being perpendicular to a primary scanning direction. Fig. 2 is a plan view showing a portion of the optical write head when viewed from top of a light-emitting element surface from which light exits. Fig. 3 is a cross-sectional view of a head major portion.

As shown in these drawings, a FPC substrate 57 of a two layer type is adhered to a metal block 51, and light-emitting array chips 50 are die-bonded thereto. Wirings on the FPC substrate

57 and light-emitting element electrode pads on the chips are connected by wire bond. Subsequently, the metal block 51 is attached to a support member 56 by means of, for example, a bolt 53. A rod lens array 54 is preliminarily adhered to a predetermined position of the metal block 51, and a light-emitting element array drive circuit board 55 is mounted thereto. The wirings of the FPC substrate 57 are connected by coupling a connector terminal 66 at the end to a connector 64 of the drive circuit board 55.

In an apparatus such as an electrophotographic printer, the ambient temperature of the optical write head rises from room temperature at startup of the printer to a temperature of about 65°C, as a result of heating of the optical write head and heating of individual components provided in the printer. Provided that room temperature is 25°C, temperature rises 40°C from room temperature at the startup of the printer.

A related-art glass epoxy substrate having light-emitting array chips mounted thereon has a coefficient of thermal expansion of 65 x 10^{-6} deg^{-1} or thereabouts. FRP (composite material consisting of a glass fiber mat and thermosetting resin) is used for the side plate of an ordinary rod lens array. The coefficient of thermal expansion of FRP involves variations unique to a composite material (i.e., $6x10^{-6}$ deg^{-1} to $16x10^{-6}$ deg^{-1}). Control of the variations is difficult.

In a case where a photosensitive drum requires an exposure

length of 320 mm (so as to comply with a size slightly larger than A3, the extent to which a substrate having light-emitting elements mounted thereon is to expand is 65×10^{-6} deg^{-1} x 40 deg. x 320 mm = 0.83 mm. The extent to which SLA is to expand is 6×10^{-6} deg^{-1} x 40 deg. x 320 mm = 0.077 to 0.20 mm. When the point on one end of the optical write head is taken as a reference position, a maximum difference in coefficient of thermal expansion arising between the substrate and the rod lens array in its lengthwise direction is 0.76 mm.

The diameter of a high-resolution rod lens is about 0.6 to 1 mm. The lens provided on the end opposite to the reference position is offset from the light-emitting elements by about one lens element. Per-lens variations in coupling efficiency of a lens and inconsistencies in light-quantum cycle induce changes in a corrected light-quantity value, which in turn induces inconsistencies in the amount of light.

Further, variations in coefficient of thermal expansion of the glass epoxy substrate stemming from heating of light-emitting elements elongate the width of an image appearing on a light-receiving surface by 0.8 mm.

In order to prevent deterioration in image quality, which would otherwise be induced by temperature variations, the following means is employed in the present invention.

Homogeneous material having a high degree of plane smoothness and a low coefficient of thermal expansion is desirable as material

for the side plate of the rod lens array. Soda lime glass, which is a low-cost material, has a coefficient of thermal expansion of about 8.8×10^{-6} deg^{-1} and matches the above-described requirements.

A conceivable measure to prevent variations in relative position between the light-emitting array chip and the lens element stemming from changes in temperature is to use material having a low coefficient of thermal expansion for the substrate and the rod lens array. Finding another material is difficult, in view of ease of working and costs. For this reason, there is employed a method of allowing given thermal expansion and taking the thermal expansion into account.

In connection with the structure of the related-art optical write head, variations in the position of the light-emitting elements due to temperature changes depend on the temperature characteristic of a substrate on which light-emitting elements are to be bonded, in the same manner as mentioned previously. For this reason, there must be selected a material whose coefficient of thermal expansion is close to that of a rod lens array having a glass side plate; that is, a thermal expansion coefficient of 8.8×10^{-6} deg^{-1}. As an insulating material for a substrate set forth, there can be employed ceramic, such as alumina, as provided in Table 1. However, a ceramic circuit board encounters difficulty in stacking patterns on the board, thus resulting in an increase in the area of the board. Further,

such an insulating material is comparatively expensive.

For this reason, the present invention provides an optical write head for solving these problems. Fig. 3 is a cross-sectional view showing the principal section of the optical write head according to the present invention. In an FPC substrate 57, copper foil wiring patterns 61 and 62 are laid on the surface of a resin layer 58 formed from high-temperature-resistant resin such as polyimide. The FPC substrate 57 is bonded to a metal block 251 formed from metallic material, by means of a thermosetting adhesive 65. Light-emitting element array chips 50 are arranged and mounted in predetermined positions on the FPC substrate 57 bonded onto the metal block 51. The light-emitting element array chips 50 are arranged by means of a die bonder and fixed by means of a conductive adhesive. Before assembly of the FPC substrate 57 into an optical write head, the light-emitting array chips 50 and the FPC substrate 57 are electrically connected together through use of Au lines 63, by means of wire bonding.

As shown in Fig. 1, the metal block 51 is secured onto a support member 56 having rigidity, by means such as a bolt 53. The rod lens array 54 is bonded to a predetermined position on the support member 56. The drive circuit board 55 is also secured to the support member 56. The other end of the FPC substrate 57 is connected to a connector 64 provided on the drive circuit board 55.

Since the FPC substrate 57 is formed from resin such as

polyimide, the resin by nature possesses a very high coefficient of thermal expansion, as provided in Table 1. However, the resin is a thin and flexible material. The extent to which resin is to thermally expand is substantially determined by the extent to which the material bonded to the metal block 51 is to thermally expand. Accordingly, the only requirement is that a material which is to thermally expand to the same extent as the rod lens array 54 be selected as material for the metal block 51.

When 45% nickel steel having a thermal expansion coefficient of 8.1×10^{-6} deg^{-1} is employed as material for the metal block 51, the extent to which the light-emitting element array chips 50 are to thermally expand is 8.1×10^{-6} $deg^{-1} \times 40$ deg $\times$ 320 mm = 0.10 mm for a size slightly larger than A3. The extent to which the optical write head according to the present invention is to thermally expand can be made 0.73 mm smaller than that to which a related-art optical write head formed from a glass epoxy substrate is to thermally expand. The percentage of change in the width of an image due to a temperature change (e.g., a change from 25°C to 65°C) can be reduced from 0.26% to 0.03%.

Moreover, as shown in Table 1, Ti has a thermal expansion coefficient of about 7×10^{-6} deg^{-1}, and this material can also be used for the metal block 51.

The amount of light is usually corrected while the optical write head is separated from a printer. A light-receiving element is situated at a position where an image is to be formed, and

the distribution of light quantity is determined. In order to make the distribution of light quantity flat, the amount of light is controlled by means of changing a per-chip current to be supplied to the light-emitting elements. At this time, there is a necessity of setting ambient temperature to the temperature of the surroundings of the optical write head arising during operation of the printer, thereby enabling effective correction of the distribution of light quantity during actual operation of the printer. However, the present invention obviates a necessity of temperature setting. Even if changes arise in the temperature of the optical write head during operation, correction of light quantity remains effective.

Since the glass epoxy substrate is material which is less likely to conduct heat (having a thermal conductivity of 0.38 $W/m_{\circ}k$), the amount of heat liberated from the optical write head is low, and hence a rise in the temperature of the light-emitting array chips becomes greater. The amount of light emitted by a GaAs-based light-emitting element is known to drop about 0.5% as the temperature of the light-emitting element chip rises by 1°C. Hence, a rise in the temperature of the light-emitting array chip accounts for a drop in the amount of light, with the result that a print speed is decreased. Further, if the substrate dissipates less heat than light-emitting array chip, a difference in the temperature distribution of the light-emitting element array chips 50 in its lengthwise direction is increased, thus

resulting in an increase in unevenness in the amount of light in the secondary scanning direction.

As shown in Fig. 3, in the structure of the optical write head according to the present invention, only the resin (polyimide) layer 58 of 25 μm thickness and the copper foil 62 of 18 μm are interposed between the light-emitting array chips 50 and the metal block 51. The heat developing in the light-emitting element array chips 50 is readily propagated to the metal block 51 serving as a heat sink. Hence, a difference in the heat distribution of the light-emitting element array chips 50 and a rise in the temperatures of all the light-emitting element array chips 50 can be reduced. Preferably, the FPC substrate 57 can be made as thin as possible.

According to thermal analysis data, a difference in temperature distribution of a glass epoxy substrate structure is estimated as 0.041°C, and that of a flexible printed wiring board structure of the same geometry is estimated as 0.08°C. Use of the flexible printed wiring board results in a temperature rise being dropped from 16°C to 6°C.

The above description has explained the means for preventing changes in the temperature of the optical write head during use. However, temperature variations arise even in a process of assembling an optical write head. As mentioned above, the light-emitting element array chips 50 are bonded to the copper

foil 62 laid on the FPC substrate 57, by use of a conductive adhesive. Curing a conductive adhesive usually requires a heating operation at a temperature of about 150°C. Hence, the light-emitting element array chips 50 and the metal block 51 are bonded at this curing temperature while they are in an expanded state. If a difference exists in thermal expansion coefficient between the light-emitting element array chips 50 and the metal block 51, stress arises when they are cooled to room temperature. Such stress induces distortion in the light-emitting element array chips 50 or the FPC substrate 57. Cracking may arise in the light-emitting element array chips 50, or warpage may arise in the FPC substrate 57. Consequently, even when the light-emitting element array chips 50 are positioned correctly through use of a die bonder, there may arise a case where the chips deviate from the location where they have been positioned after bonding.

GaAs has a coefficient of thermal expansion of about 6 x 10^{-6} deg^{-1}. In a case where the light-emitting element array chips 250 are formed from GaAs-based semiconductor, 42% nickel steel having a thermal expansion coefficient of 8.1 x 10^{-6} deg^{-1} and Ti having a thermal expansion coefficient of about 7 x 10^{-6} deg^{-1}, both having been described previously, are substantially equal in coefficient of thermal expansion to GaAs, and either can be used as material suitable for this case.

A related-art LED array can be applied to a light-emitting

element array to be used in the optical write head according to the present invention. Use of a self-scan-type light-emitting element array is more preferable. The reason for this is that the self-scan-type light-emitting element array obviates a necessity of interconnecting a light-emitting element and a driver IC in a one-to-one relationship. The self-scan-type light-emitting element array is suitable for a case where a substrate having a light-emitting element array mounted thereon is separated from a substrate having driver ICs mounted thereon.

Fig. 4 shows an equivalent circuit diagram of the self-scan-type light-emitting array (as described in Japanese Patent Application Laid-Open No. 263668/1990). The light-emitting device is formed from an array consisting of transfer thyristor elements T(1), T(2), … and light-emitting thyristor elements L(1), L(2), … The drawing shows only a portion of the array. The transfer thyristor elements T(1), T(2), … are interconnected by means of diodes D1, D2, … V_{GA} denotes a power line (usually assuming -5V) which is connected to a gate electrode of each of the thyristor elements T and L. A start pulse signal ϕ_3 is applied to the gate electrode of the thyristor element T(1). Clock pulse signals ϕ_1 and ϕ_2 are applied to the cathode electrodes of alternating thyristor elements T. The gate electrodes of the transfer thyristor elements T(1), T(2), … and the corresponding gate electrodes of the light-emitting thyristor elements are interconnected by means of wires G(1),

G(2), … A write signal ϕ_I is applied also to the cathode electrodes of the light-emitting thyristor elements L.

In the above-described circuit configuration, the thyristor elements T(1), T(2), … are sequentially turned on by means of the two clock pulse signals ϕ_1 and ϕ_2. In association with such turning-on action, the light-emitting thyristors L(1), L(2), … enter a state in which they can be turned on sequentially. If any one of light-emitting thyristor elements is turned on or enters a luminous state, the luminous intensity of the light-emitting thyristor element is determined by the amount of electric current to flow as a write signal ϕ_I; that is, resistance R_I. An image can be written at arbitrary intensity. As can be seen from Fig. 5, the self-scan-type light-emitting array of such a configuration requires interconnection of only a total of six terminals per chip; that is, two power terminals and four signal terminals. Thus, the number of connections does not depend on the number of light-emitting elements mounted on one chip. Hence, in a case where 128 light-emitting elements, for example, are mounted per chip, the number of wires to be connected to a drive IC per chip can be reduced to one-twentieth those required for a related-art LED array chip.

By replacing a related-art LED array chip with the self-scan-type light-emitting array chip, a driver IC can be readily mounted on a substrate differing from that having

light-emitting elements mounted thereon (see Japanese Patent Application Laid-Open No. 187981/1997). Such a construction can be said to be a method for reducing the width of the substrates and miniaturizing an optical write head more effectively than a method using the related-art LED array chip.

TABLE 1

MATERIAL	THERMAL CONDUCTIVITY (W/m•K)	COEFFICIENT OF THERMAL EXPANSION (10^{-6} deg^{-1})
GLASS	0.76	8.8
Cu	339	16.5
Ti	27	7.0
Ni ALLOY	13.4	8.1
POLYIMIDE	0.1	170
FRP	-	6 THROUGH 16
GaAs	-	6.0

[Effect of the Invention]

According to the present embodiment, there can be prevented a misalignment between the optical axis of an optical write head and the optical axis of a light-emitting element, which would otherwise be caused by temperature variations arising during assembly or operation of the optical write head. Accordingly, occurrence of inconsistencies in the density of an image can

be prevented. There is also obviated a necessity for managing the temperature of the optical write head when the distribution of light quantity is measured for correcting light quantity. Further, dissipation of heat from the light-emitting elements is improved. Hence, variations in the distribution of light quantity of light-emitting array chips due to temperature variations can be reduced. There can be prevented occurrence of inconsistencies in density of an image, which would otherwise be caused by variations in the distribution of light quantity.

[Brief Description of the Drawings]

Fig. 1 is a side view of an optical write head according to the present invention;

Fig. 2 is a plan view showing a portion of the optical write head according to the present invention having light-emitting element array chips mounted thereon;

Fig. 3 is a cross-sectional view showing the principal section of the optical write head according to the present invention;

Fig. 4 is an equivalent circuit diagram showing a self-scan-type light-emitting element array;

Fig. 5 is a schematic view showing the principle of an optical printer equipped with an optical write head;

Fig. 6 is a schematic cross-sectional view showing the construction of a related-art optical printer head.

[Description of Reference Numerals]

2 photosensitive drum

6 optical write head

30,50 light-emitting element array chip

31 driver IC chip

32,42 substrate

33,63 Au line

34,54 rod lens array

51 metal block

55 drive circuit board

56 support member

57 flexible printed circuit substrate

58 resin layer

61,62 copper-foil wiring pattern

65 thermosetting adhesive

[Document Name] Abstract

[Abstract]

[Object]

There may be a case where the optical axis of a light-emitting array chip and the optical axis of a rod lens may deviate from an initially-adjusted position in an optical write head due to temperature variation. Inconsistencies in an image stemming from such deviation cannot be compensated by the electrical correction of light quantity.

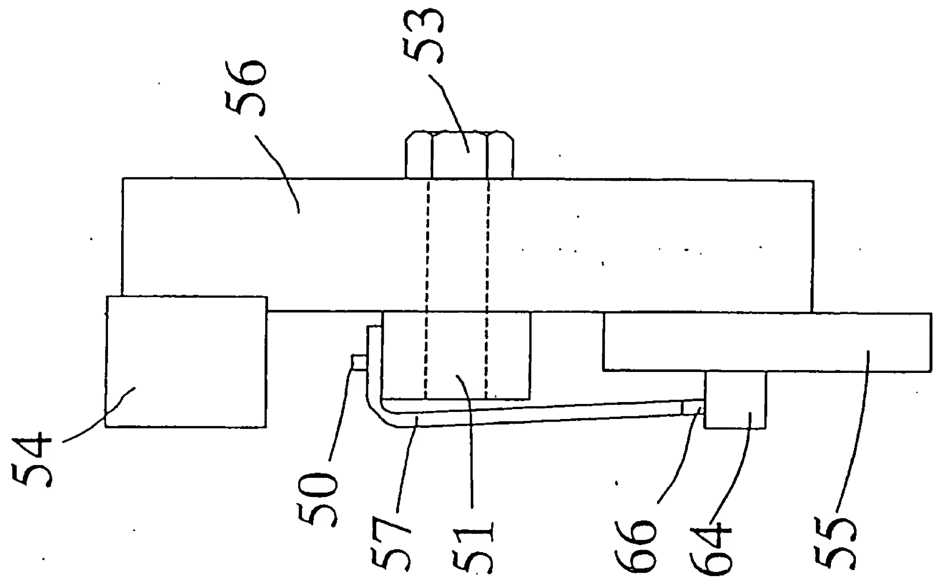
[Solution]

An optical write head comprising a flexible circuit board 57 remaining in close contact with a metal block 51, and a plurality of light-emitting element array chips 50 arranged on the flexible circuit board in a straight line or in a staggered layout so as to oppose a gradient index rod lens array 54, each of the light-emitting array chips 50 having a light-emitting element array, wherein the metal block 51 is a metallic member substantially equal in coefficient of thermal expansion to the rod lens array 54 and the light-emitting element array chips 50. Preferably, a side plate of the rod lens array 54 is formed from glass, and the metallic member is a nickel alloy or titanium. Further, in this arrangement, the light-emitting element array is preferably a self-scan-type light-emitting element array.

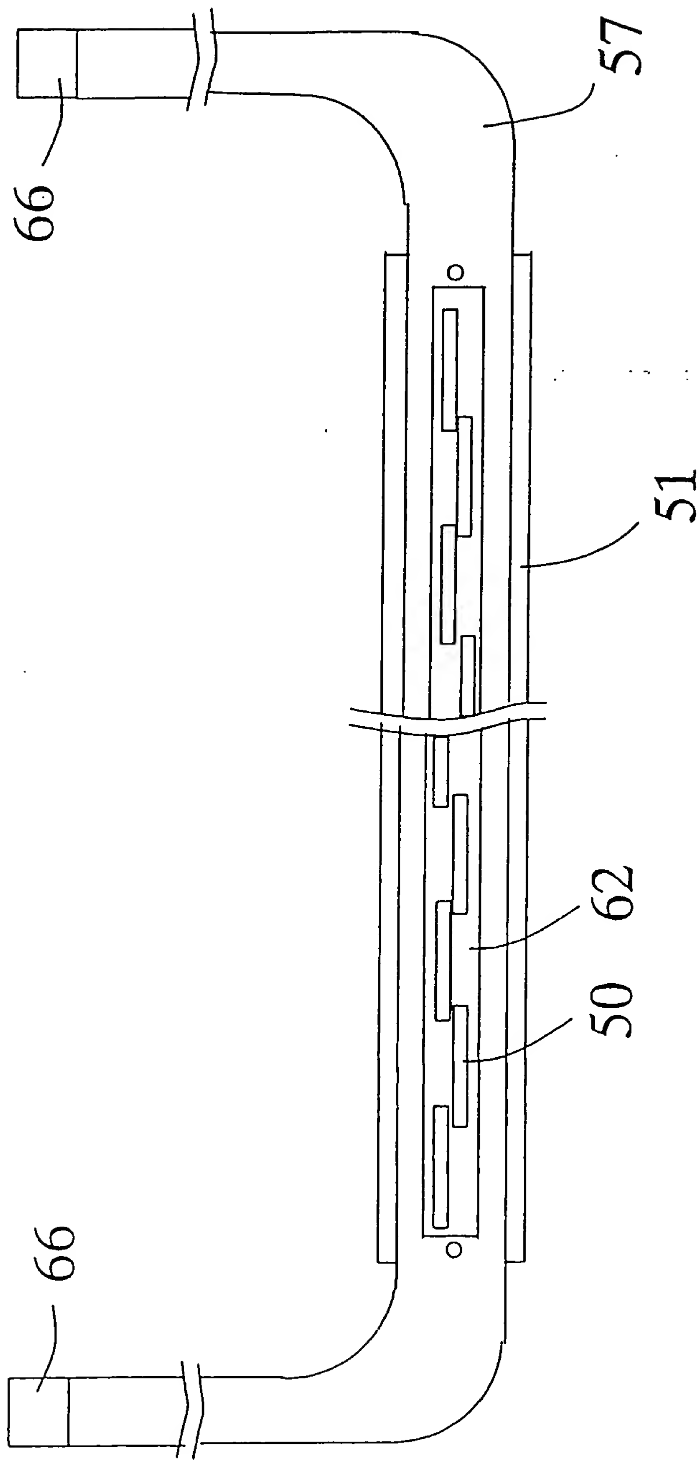
[Selected Drawing] Fig. 1

[Name of Document] Drawings

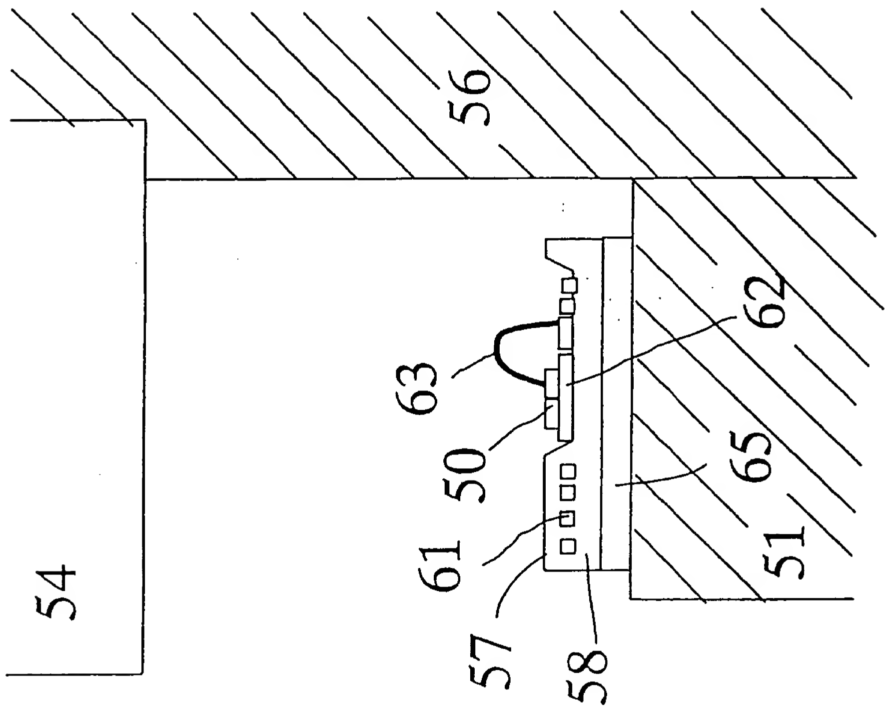
[Fig. 1]



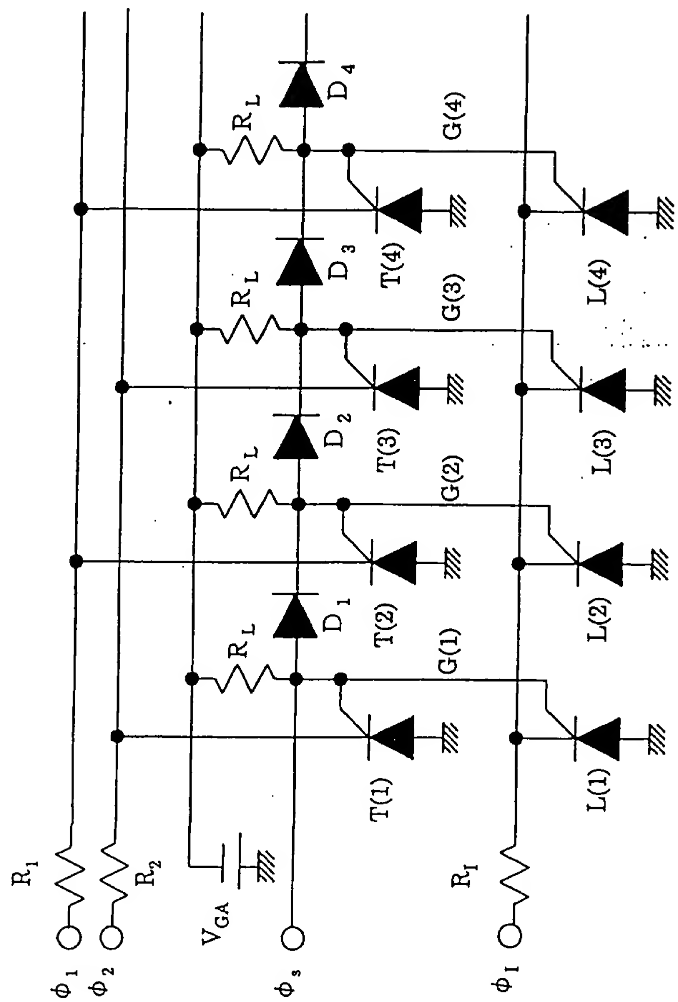
[Fig. 2]



[Fig. 3]



[Fig.4]



ϕ_1
ϕ_2
R_1
R_2
V_{GA}
ϕ_s
R_I
ϕ_I
R_L
D_1
D_2
D_3
D_4
T(1)
T(2)
T(3)
T(4)
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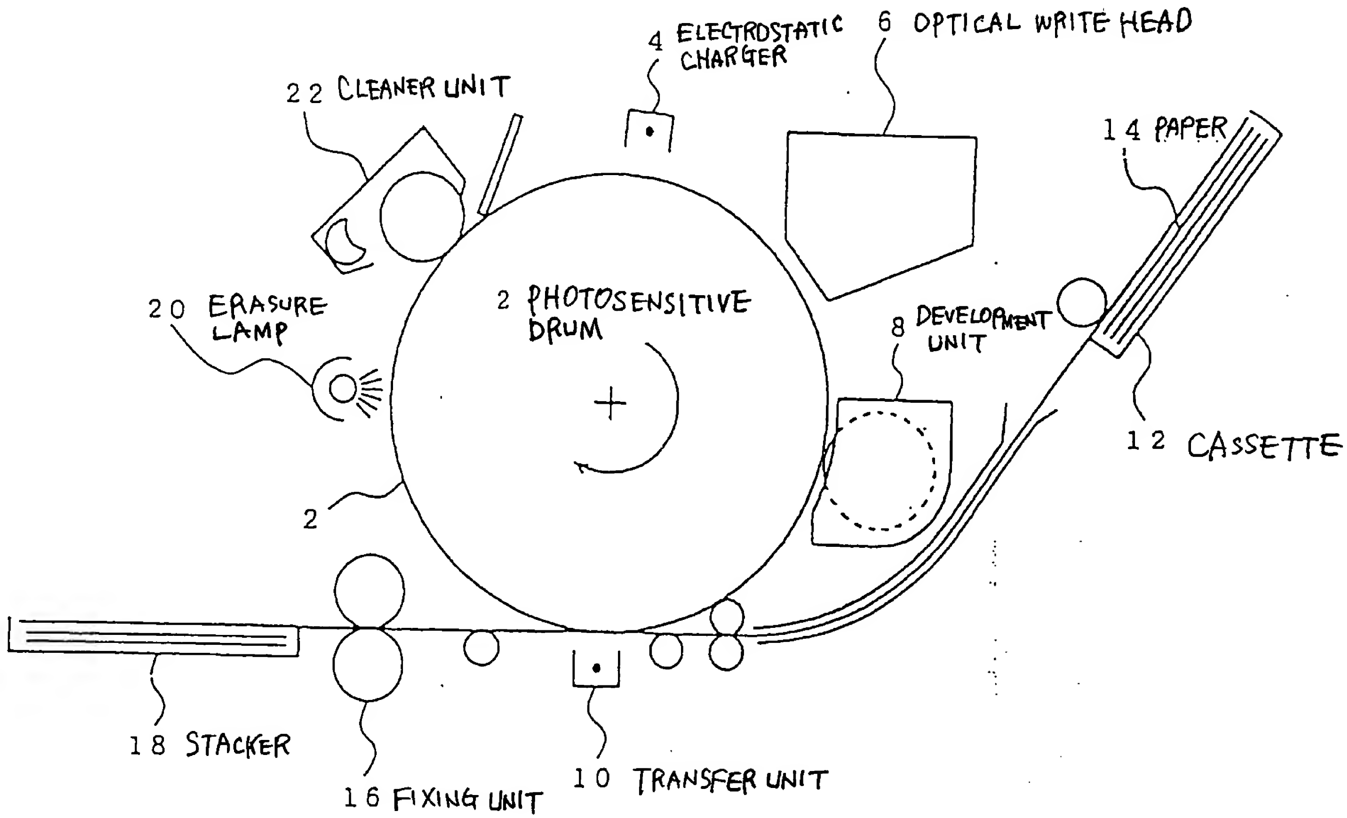
L(3)
L(4)

[Fig. 5]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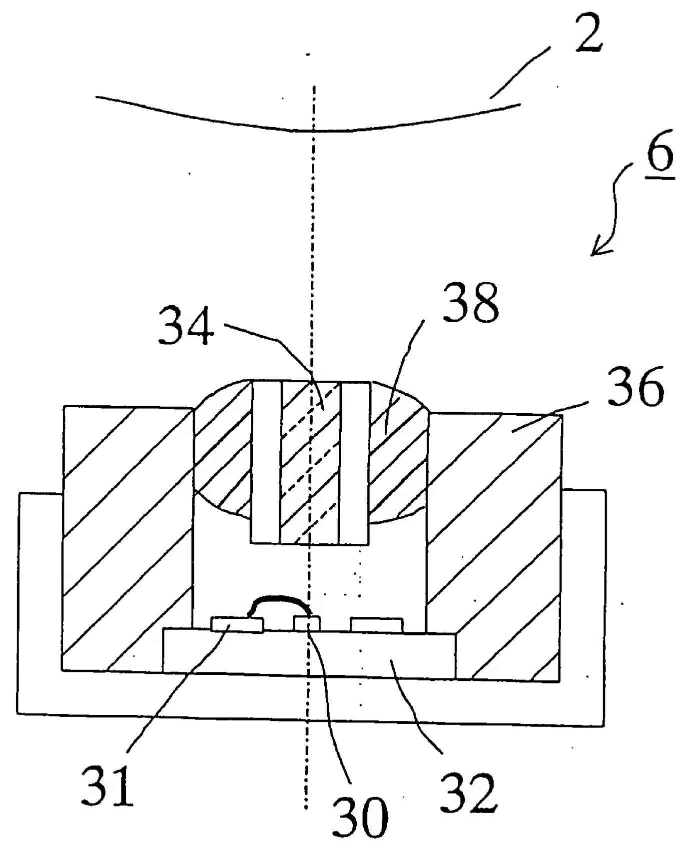
[Fig 6]



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This is to certify that the annexed is a true copy of the following application as filed with this office.

Date of Application: July 13, 2000

Application Number: Patent Application No.2000-213005

Applicant(s): NIPPON SHEET GLASS CO., LTD.

May 25, 2001

Commissioner,
Patent Office

Kozo OIKAWA (Seal)

Issuance No. 2001-3043292

[DOCUMENT NAME] Patent Application

[REFERENCE NUMBER] 00P114

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[AMOUNT OF PAYMENT] 21000

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[DOCUMENT NAME] Specification 1

[DOCUMENT NAME] Drawing 1

[DOCUMENT NAME] Abstract 1

[GENERAL POWER OF ATTORNEY NO.] 9706787

[REQUEST FOR PROOF] Yes

[Document Name] Specification

[Title of the Invention] Optical Write Head and Method of Assembling the same

[Claims]

[Claim 1] An optical write head comprising a substrate, and a plurality of light-emitting element array chips arranged on the substrate in a straight line or in a staggered layout so as to oppose a gradient index rod lens array, each of the light-emitting array chips having a light-emitting element array, wherein the light-emitting element array chips are mounted directly on a flexible printed circuit board.

[Claim 2] The optical write head according to claim 1, wherein the reverse surface of a light-emitting array chip mount section of the flexible printed circuit board is disposed in close contact with a member having rigidity.

[Claim 3] The optical write head according to claim 1, wherein the flexible printed circuit board is of multilayer type and comprises a resin layer and a copper foil, and no adhesive is interposed between the resin layer and the copper foil.

[Claim 4] The optical write head according to claim 1, wherein the flexible printed circuit board has a thickness of 30 to 50 μm.

[Claim 5] The optical write head according to any one of claims 1 to 3, wherein the light-emitting array is a self-scan-type

[redacted]

light-emitting array.

[Claim 6] The optical write head according to claim 1, wherein reference position marks for specifying respective positions at which the light-emitting array chips are to be arranged are provided on the surface of the member which has rigidity and is disposed in close contact with the flexible printed circuit board.

[Claim 7] A method of assembling an optical write head, comprising the steps of:

bonding a portion of a flexible printed circuit board to a member having rigidity;

arranging a plurality of light-emitting element array chips at predetermined positions on the flexible printed circuit board in the form of a straight line or in a staggered layout and bonding the light-emitting element array chips directly to the flexible printed circuit board;

electrically connecting the light-emitting array chips to predetermined wire bonding pads provided on the flexible printed board by means of wire bonding; and

fixing the member having rigidity at a predetermined position on a support member having a rod lens array and a light-emitting element array driver circuit board mounted thereon beforehand.

[Detailed Description of the Invention]

[Field of the Invention]

The present invention relates to an optical write head used,

for instance, in an electrophotographic printer, using light-emitting element array chips.

[Related Art]

An optical write head to be used in an optical printer has hitherto been equipped with light-emitting element arrays, such as light-emitting diodes. The principle of an optical printer equipped with an optical write head (an optical printer head) is illustrated in Fig. 5. The surface of a cylindrical photosensitive drum 2 is coated with material (photosensitive material) possessing optical conductivity, such as amorphous Si or organic material. The photosensitive drum 2 rotates in accordance with a print speed. To begin with printing, the surface of photosensitive material provided over a rotating drum is charged uniformly with an electrostatic charger 4.

Next, an optical write head 6 radiates, onto the photosensitive material, light which assumes the image of a dot to be printed, thereby neutralizing the thus-exposed portion of the photosensitive material and forming a latent image. Subsequently, a development unit 8 causes toner to adhere to the photosensitive material in accordance with the charged status of the photosensitive material. A transfer unit 10 transfers toner onto paper 14 supplied from a cassette 12. A fixing unit 16 applies heat to the paper, thereby fixing the toner transferred on the paper. The paper is then fed to a stacker 18. After transfer of the latent image has been completed, the entirety of the

electrically-charged photosensitive drum 2 is neutralized by an erasure lamp 20, and residual toner is removed by a cleaner unit 22.

As shown in a cross-sectional view of Fig. 6, in the optical write head 6, a plurality of light-emitting element array chips 30 are arranged in a single line on a printed circuit board 32 formed from glass epoxy, in accordance with specifications pertaining to a print width. A rod-lens array 34 having gradient index rod lenses stacked thereon in the form of one or two lines is arranged opposite the light-emitting element array chips 30. The light-emitting element array chips 30 and the rod lens arrays 34 are fixed on a housing 36 by means of a silicon filler 38.

In principle, in a primary scanning direction (i.e., the direction in which light-emitting points are to be scanned; that is, a direction perpendicular to a sheet of Fig. 6), the optical write head 6 having the light-emitting element array chips 30 arranged thereon must be made greater in size than a print width. In order to reduce the overall size of a printer using the optical write head 6, demand exists for reducing the size of the printer in a secondary scanning direction (i.e., a direction in which the photosensitive drum 2 rotates). As shown in Fig. 6, the printed circuit board 32 having the light-emitting array chips 30 mounted thereon must be arranged perpendicular to a light-emission optical axis 39. For this reason, a reduction in the width of the substrate 32 is effective for reducing the

dimension of the printer in the secondary scanning direction.

A light-emitting diode (LED) array is commonly and widely used as a light-emitting array. Supply of a signal corresponding to an image signal output from a driver integrated circuit (IC) to LED chip arrays requires formation of bonding pads (BPs) equal in number to LED elements on the LED array chip 30. In the case of a resolution of 600 dpi, a pitch at which LED elements are to be arranged is 42.3 μm. Provided that a side of an area in which bonding pads (BP) are arranged is 80 μm, a pitch at which BPs are to be arranged is 80 μm or more. At least two rows of BPs must be arranged in the direction parallel to the direction in which LEDs are arranged.

In a case of manufacture of a print head of 600 dpi for A3-size paper, light-emitting points to be arranged in a one-dimensional layout assume a number of 7,000 or more. Wire bonds (WB) equal in number to the light-emitting points must be connected to a driver IC. Hence, driver IC chips 31 are die-bonded to the substrate on which the light-emitting array chips 30 are mounted. The driver IC chips 31 are connected to the light-emitting array chips 30 through use of an Au line 33 and by means of wiring bonding.

A driver IC chip must be disposed on either side of an LED array chip having a high density of light-emitting points for use with a high-definition printer. For this reason, difficulties

are encountered in reducing the width of the substrate 32 to a certain extent or more. The substrate 32 on which the driver IC chip 31 is disposed on either side of the light-emitting array chip 30 usually assumes a width of about 12 mm to 20 mm.

A space of 5 mm to 10 mm width is required for mounting connectors for drawing wires from the substrate 32 or for soldering a flexible printed circuit board.

In order to prevent an increase in the width of the substrate 32, which would otherwise be caused by ensuring a wiring space, the related-art technique has hitherto employed a method of elongating a substrate in a primary scanning direction and mounting connectors in a range on the substrate where no light-emitting element array chips are to be present, through use of through holes; a method of mounting connectors on the reverse surface of a substrate by means of surface mount technique; or a method of mounting a flexible printed circuit board on the reverse side of a substrate by means of soldering.

In order to reduce the number of wires to be bonded to the LED arrays, inventions have been proposed [Japanese Patent Application Laid-Open Nos. 238962(1989), 14584(1990), 92650(1990), and 92651(1990)], wherein light-emitting thyristors of a p-n-p-n structure are adopted as constituent elements of the light-emitting array, thereby enabling self-scanning of light-emitting points. The inventions describe the ability to facilitate mounting of light-emitting thyristors as a light source

for an optical printer, to reduce an area within which light-emitting elements chips are to be mounted, and to manufacture a compact light-emitting device.

Further, an invention has been proposed [Japanese Patent Application Laid-Open No. 263668(1990)], in which a switching element array is taken as a transfer section and is isolated from a light-emitting element (i.e., light-emitting thyristor) array.

Fig. 7 shows an equivalent circuit of the self-scan-type light-emitting array. The light-emitting device is made up of an array of transfer thyristor elements T(1), T(2), … and light-emitting thyristors L(1), L(2), … The drawing shows only a portion of the array. The transfer thyristor elements T(1), T(2), … are connected by means of diodes D1, D2, … V_{GA} denotes a power line (usually assuming -5V) which is connected to a gate electrode of each of the thyristor elements T and L. A start pulse signal ϕ_S is applied to the gate electrode of the thyristor element T(1). Clock pulse signals ϕ_1 and ϕ_2 are applied to cathode electrodes of alternating thyristor elements T. The gate electrodes of the transfer thyristor elements T(1), T(2), … and the corresponding gate electrodes of the light-emitting thyristor elements are interconnected by means of wires G(1), G(2), … A write signal ϕ_I is applied also to the cathode electrodes of the light-emitting thyristor elements L.

In the above-described circuit configuration, the thyristor elements T(1), T(2), … are sequentially turned on by means of the two clock pulse signals ϕ_1 and ϕ_2. In association with such turning-on action, the light-emitting thyristors L(1), L(2), … enter a state in which they can be turned on sequentially. If any one of light-emitting thyristor elements is turned on or enters a luminous state, the luminous intensity of the light-emitting thyristor element is determined by the amount of electric current to flow as a write signal ϕ_I; that is, by resistance R_I. An image can be written at arbitrary intensity. As can be seen from Fig. 7, the self-scan-type light-emitting array of such a configuration requires interconnection of only a total of six terminals per chip; that is, two power terminals and four signal terminals. Thus, the number of connections does not depend on the number of light-emitting elements mounted on one chip. Hence, in a case where 128 light-emitting elements, for example, are mounted per chip, the number of wires to be connected to a drive IC per chip can be reduced to one-twentieth those required for a related-art LED array chip.

By replacing a related-art LED array chip with the self-scan-type light-emitting array chip, a driver IC can be readily mounted on a substrate differing from that having light-emitting elements mounted thereon (see Japanese Patent Application Laid-Open No. 187981/1997). As shown in Fig. 8, a substrate 42 having light-emitting element array chips 40 mounted

[redacted]

thereon is disposed opposite a rod lens array 44. A substrate 45 having the driver IC mounted thereon is separated from the substrate 42. The substrates 42 and 45 are connected together by means of a flexible printed circuit (FPC) board 47. The FPC substrate 47 is connected to the substrates 42 and 45 by means of soldering or through use of connectors. Such a construction can be said to be a method of reducing the width of the substrates and miniaturizing an optical write head more effectively than a method using the related-art LED array chip.

[Problems to be solved by the Invention]

As mentioned above, in a case where the substrate having light-emitting elements mounted thereon is separated from the substrate having a driver IC mounted thereon, a certain number of wires to be used for interconnecting the substrates are required. The wires are greater in number than those required when drawing wires, to the outside, from a substrate having light-emitting elements and a driver IC mounted thereon. The wires can be integrated simply by use of an FPC substrate. However, much space to be used for mounting connectors or space for soldering must be ensured on the substrate having light-emitting elements mounted thereon. Hence, the width of the substrate cannot be diminished much.

The present invention has been conceived to solve the drawback set forth and is aimed at providing a compact optical write head which substantially obviates a necessity of optical adjustment,

thereby embodying a high-resolution electrophotographic printer.

[Means for solving the problems]

According to the present invention, there is provided an optical write head in which light-emitting array chips are mounted directly on a flexible print circuit (FPC) substrate. The FPC substrate is brought, in advance, into close contact with a member possessing rigidity. The FPC substrate is of multilayer type and preferably has a thickness of 30 to 50 μm. As to the optical write head according to the present invention, a self-scan-type light-emitting element array is suitable as the light-emitting element array.

The optical write head according to the present invention is assembled in the following manner. A portion of the FPC substrate is bonded in advance to a member having rigidity. Next, light-emitting array chips are arranged on and directly die-bonded to the FPC substrate in the form of a straight line or in a staggered layout. Wire bonding pads provided on the light-emitting element array chips and wire bonding pads provided on the FPC substrate are electrically interconnected by means of wire bonding. Subsequently, the member having rigidity is mounted at a predetermined position on a support member having the rod lens array and the light-emitting array driver circuit mounted thereon.

The present invention proposes direct die-bonding of light-emitting array chips onto an FPC element. As a result, a necessity of interconnecting the substrate having light-emitting

elements mounted thereon and the driver circuit using a connector can be obviated. Since mounting of connectors to the substrate is obviated, the area of the substrate can be minimized correspondingly.

Accurately arranging and fixing chips on a flexible substrate is not easy. Further, wire-bonding chips onto resin which poses difficulty in propagation of ultrasonic waves is also difficult. For these reasons, a member having rigidity is brought into close contact with the reverse side of an area of the substrate at which chips are to be mounted. Further, the thickness of the FPC substrate is made as small as possible. In this state, the precision of positions of chips required by the optical write head can be ensured by means of die-bonding or wire-bonding light-emitting array chips on the substrate. Further, electrical connection can be established easily. There can be prevented deformation of the area of the substrate in which chips have been mounted, which would otherwise be caused when the chips are mounted. Further, breakage of wire-bonded Au lines or rupture of chips can be prevented.

In a case where wires must be drawn to either side of a chip because of design of a light-emitting element array chip, wires can be drawn readily by use of an FPC substrate of multilayer type. By means of such a construction, the substantial area of the substrate can be reduced much further, thereby improving the freedom of design of an optical write head.

A member which has rigidity and is mounted on an FPC substrate is embodied as a single constituent component of an optical write head, thereby enabling very simple and highly accurate assembly of an optical write head.

[Embodiment of the Invention]

An embodiment of the present invention will be described hereinbelow by reference to Figs. 1 through 4. Fig. 1 is a side view showing the side of an optical write head according to the present invention, the side being perpendicular to a primary scanning direction. Fig. 2 is a plan view showing a portion of the optical write head on which a light-emitting element array chip is mounted when viewed from top of a surface from which light exits. Fig. 3 is a partially-enlarged view of the plan view shown in Fig. 2. Fig. 4 is a cross-sectional view taken along line X-X′ shown in Fig. 3. In order to make the drawings easily understandable, the drawings are partially simplified. For this reason, the number of patterns and wire bonds on an FPC circuit board is inevitably represented incorrectly.

A two-layer FPC substrate 57 has copper-foil wiring patterns 61 sandwiched between resin layers 58 formed from heat-resisting resin, such as polyimide. The FPC substrate 57 is bonded to a metal block 51 formed from metallic material, by means of a thermosetting adhesive 65 (see Fig. 4). The number of layers of FPC substrates 57 may be increased, as necessary.
Self-scan-type light-emitting element array chips 50 are mounted

into a row and at predetermined locations on the surface of copper foil 62 laid on the surface of the FPC substrate 57 bonded to the metal block 51. The array chips 50 are arranged by means of a die bonder and fixed by means of a conductive adhesive. Fig. 2 shows an example in which the array chips 50 are arranged in a staggered layout. However, the array chips 50 can be arranged in a straight line. Before the FPC substrate 57 is assembled into an optical write head, electrode pads 58 provided on the light-emitting array chips 50 having the light-emitting elements 52 mounted thereon are electrically connected, by means of wire bonding, to conductor pads 65 located at predetermined locations within an area 67 of the FPC substrate 57 from which a resin layer has been partially removed.

The light-emitting element array chip 50 having a structure such as that shown in Fig. 3 is designed for a staggered layout. In this case, the Au lines 63 cannot be provided so as to straddle the light-emitting elements 52. Hence, the bonding pads 65 to be provided on the FPC substrate 57 must be provided on either side of the respective array chips 50. In this case, use of an FPC substrate of multilayer type is an absolute requirement.

As shown in Fig. 1, a metal block 51 is subsequently mounted on a support member 56 having rigidity, by use of means such as a bolt 53. A rod lens array 54 is bonded to a predetermined location on the support member 56 through use of an adhesive. Moreover, a drive circuit board 55 is mounted on the support

[redacted]

member 56 as well. A terminal 66 provided on either end of the FPC substrate 57 is connected to a corresponding connector 64 provided on the driver circuit board 55, thereby enabling supply of a drive signal to the light-emitting elements. Such a construction enables realization of the width of the substrate in the secondary scanning direction which is two-fifths that of the related-art substrate.

The optical axis of the rod lens array 54 and the optical axes of the light-emitting elements are preferably aligned with each other, by means of only mechanically fixing the rod lens array 54 to the support member 56. Means to be used for alignment will be described later.

In order to obtain a good image, a working distance of the rod lens array 54 (i.e., distance between the end faces of rod lenses and the surfaces of the light-emitting elements) must be set to ± 30 μm of a specified value. A related-art glass epoxy substrate (having a thickness of 1.0 to 1.6 mm) has a thickness precision of ± 0.13 mm or thereabouts. In a case where the structure shown in Fig. 6 or 8 is employed, the height precision of the light-emitting element array chip depends on the thickness precision of the glass epoxy substrate and fails to fall within an allowance of ± 30 μm.

In connection with the FPC substrate, a proportional relationship exists between the thickness of a layer and its

allowance. Hence, minimizing the thickness of the FPC substrate is desirable. The present embodiment employs a copper foil having a thickness of 18 μm, an FPC substrate (having a thickness of 43 μm) having a resin sheet of 25 μm thickness, and an adhesive of 25 μm thickness applied between a metal block and the FPC substrate. The thickness precision of the FPC substrate is about 10 to 15% the total thickness of the FPC substrate. In the case of the FPC substrate employed in the present embodiment, a thickness precision of 11 μm = (25+18+25 μm)x15% can be obtained. In order to maintain the tolerance, the thickness of a layer must be set to a maximum of 100 μm. In contrast, a thinner layer is preferable. However, a copper foil cannot be made very thin. In consideration of electrical insulation, under the present circumstances the resin sheet must have a thickness of 12 μm or more. As mentioned above, we can say that the thickness of the FPC substrate preferably falls within a range of 30 to 50 μm, in terms of thickness precision and an electrical insulation characteristic.

In order to increase the ease of bonding Au lines to the FPC substrate by means of wire bonding, selection of the type of an FPC substrate which obviates use of an adhesive between a resin layer and a copper foil is desirable. The FPC substrate of this type has lower absorption of ultrasonic waves, thereby enabling a stable wire bonding operation. Further, the FPC substrate of this type has superior dimensional stability and

is suitable for accomplishing the object of the present invention.

In the present invention, light-emitting element array chips are bonded directly to the FPC substrate. At this time, if in-plane positional accuracy is not maintained, after assembly of an optical head there may arise a complicated operation necessary for aligning the optical axis of the rod lens array with the optical axes of the light-emitting elements.

The rod lens array 54 is supported and mounted on the support member 56 by means of an adhesive. Even when glass is used for the side plate of the rod lens array 54, the thickness of the rod lens array 54 has minute variations stemming from production. Even when positional precision between a reference plane A and a reference plane B of the support member 56 is improved indiscriminately, the accuracy of distance between the center of the optical axis of the rod lens array 54 and the reference plane is not ensured. Hence, the thickness of the rod lens array 254 must be measured in advance.

As measures for ensuring the precision of distance between the position at which the light-emitting array chips 50 are mounted and a mating reference plane C at which the metal block 51 and the support member 56 are bonded, reference position marks 68 spaced a given distance away from a junction surface of the support member 56 are provided on a bonding surface of the FPC substrate 57 of the metal block 51 (see Fig. 2). More specifically, two circular recesses are provided at the respective ends of a row

of the chips 50 mounted on the surface of the metal block 51. The number of marks may be increased further, and the geometry of the marks is not limited to a circular shape. The reference position marks 68 are taken as reference positions for the die bonder, and the amount of offset from the reference positions is computed from data pertaining to the thickness of the rod lens array 54. The die bonder is set by reference to the offset, thereby defining the distance between the position where the light-emitting array chips 50 are to be bonded and the reference plane C. The metal block 51 is brought into stationary and close contact with the support member 56, thereby basically enabling alignment between the optical axes of the light-emitting elements and the optical axes of the rod lenses. The thickness of the rod lens array 254 is practically leveled in accordance with a required precision.

[Effect of the Invention]

In the optical write head according to the present invention, even when a substrate having light-emitting elements mounted thereon is separated from a substrate having a driver circuit mounted thereon, the substrate having the light-emitting elements mounted thereon can be miniaturized, and hence an optical write head can be made compact. In this case, optical alignment of the optical write head in the direction of an optical axis and in the direction within a plane perpendicular to the optical axis can be obviated.

[Brief Description of the Drawings]

Fig. 1 is a side view of an optical write head according to the present invention;

Fig. 2 is a plan view showing a portion of the optical write head according to the present invention having light-emitting element array chips mounted thereon;

Fig. 3 is a partially-enlarged plan view showing a portion of the optical write head according to the present invention having light-emitting element array chips mounted thereon;

Fig. 4 is a cross-sectional view showing the principal section of the optical write head according to the present invention;

Fig. 5 is a schematic view showing the principle of an optical printer equipped with an optical write head;

Fig. 6 is a schematic cross-sectional view showing the construction of an optical printer head in a related art;

Fig. 7 is an equivalent circuit diagram showing a self-scan-type light-emitting element array; and

Fig. 8 is a schematic cross-sectional view showing the construction of another related-art optical printer head.

[Description of Reference Numerals]

2 photosensitive drum

6 optical write head

30,40,50 light-emitting element array chip

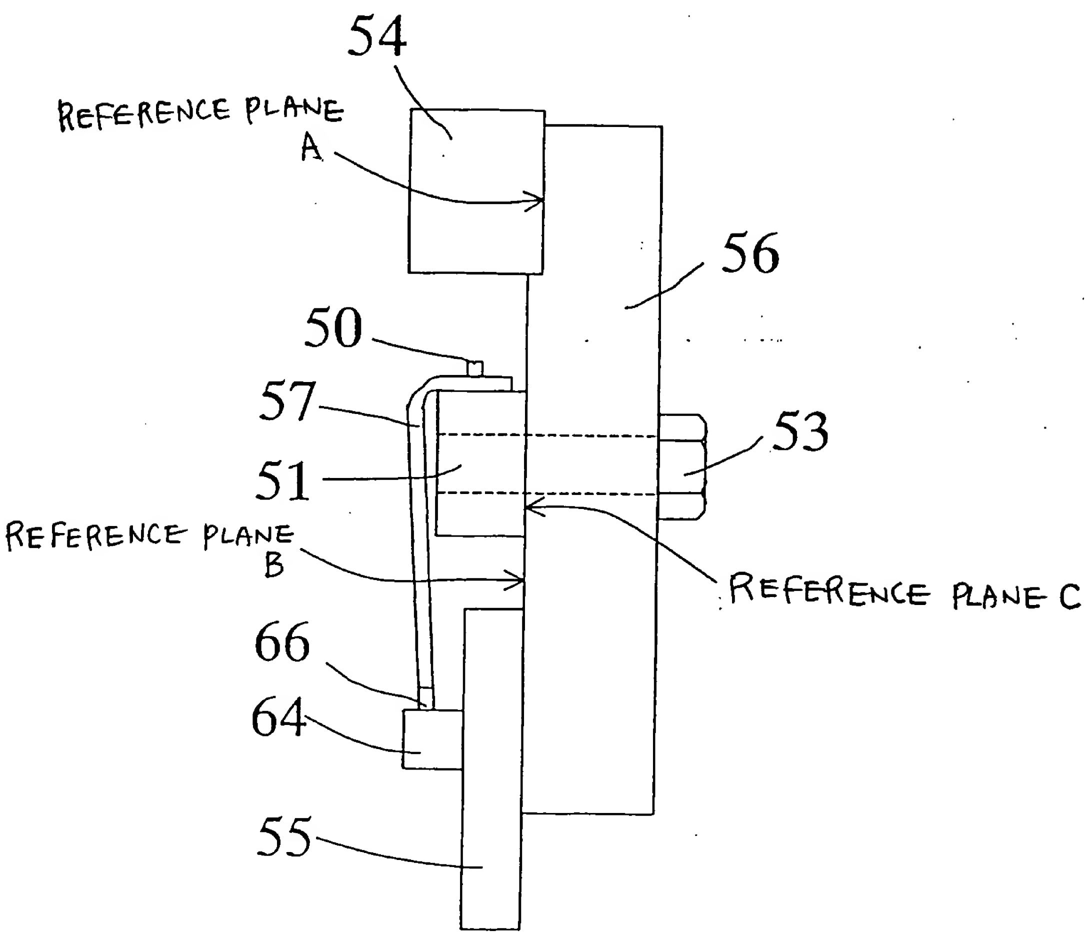
31 driver IC chip

32,42 substrate

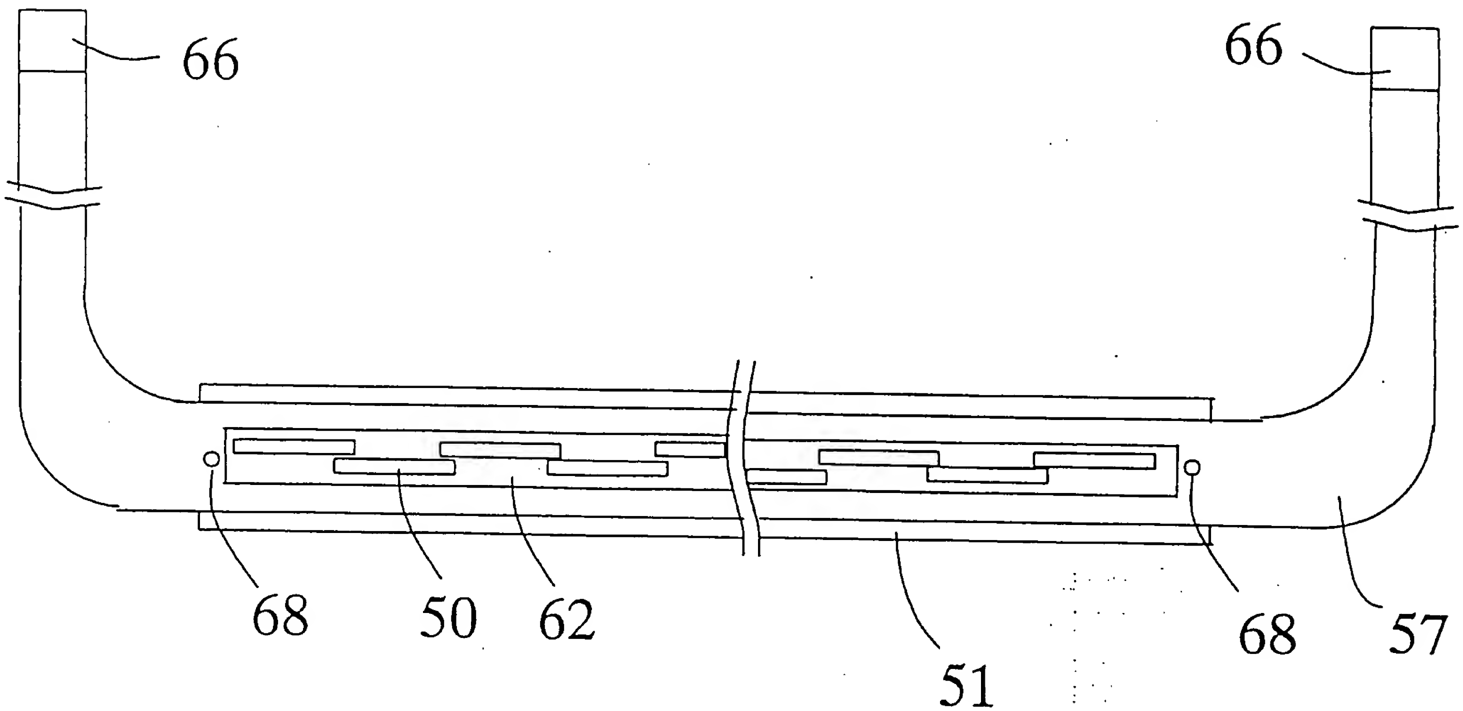
33,63	Au line
34,44,54	rod lens array
46,56	support member
47,57	flexible printed circuit substrate
51	metal block
55	drive circuit board
58	resin layer
61,62	copper-foil wiring pattern
65	thermosetting adhesive
68	reference position mark

[Name of Document] Drawings

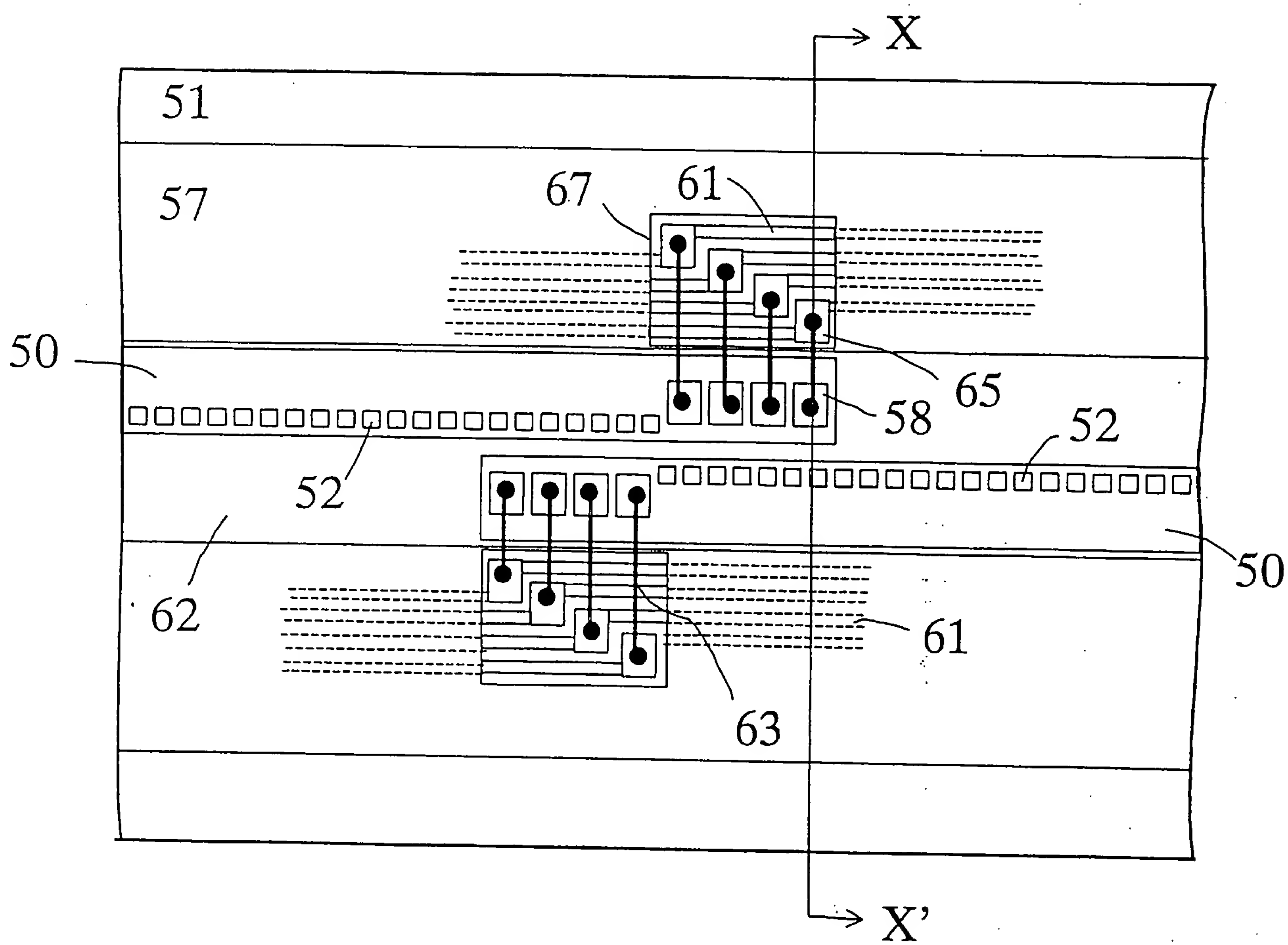
[Fig. 1]



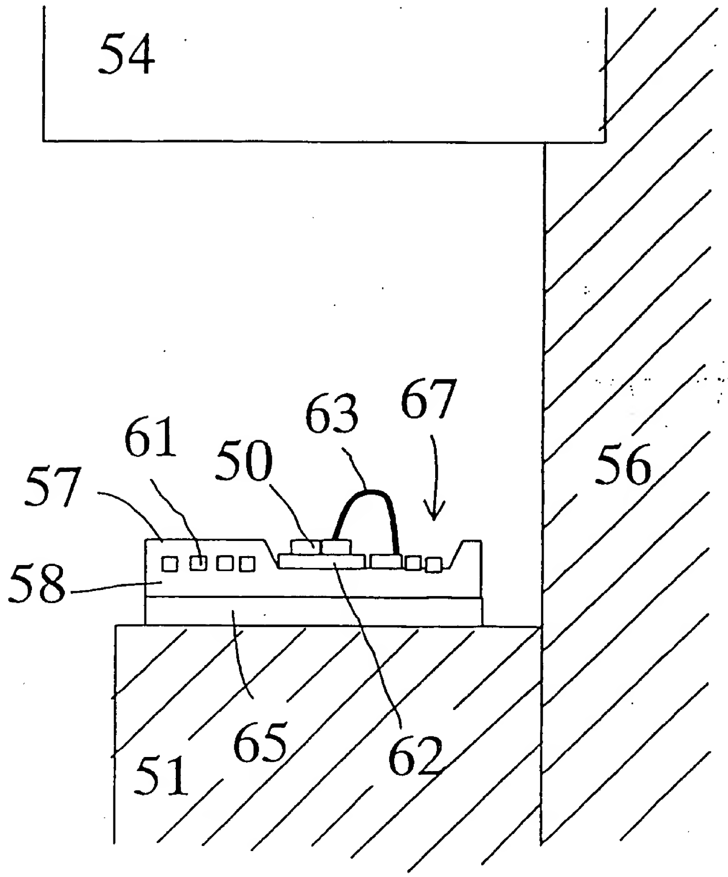
[Fig. 2]



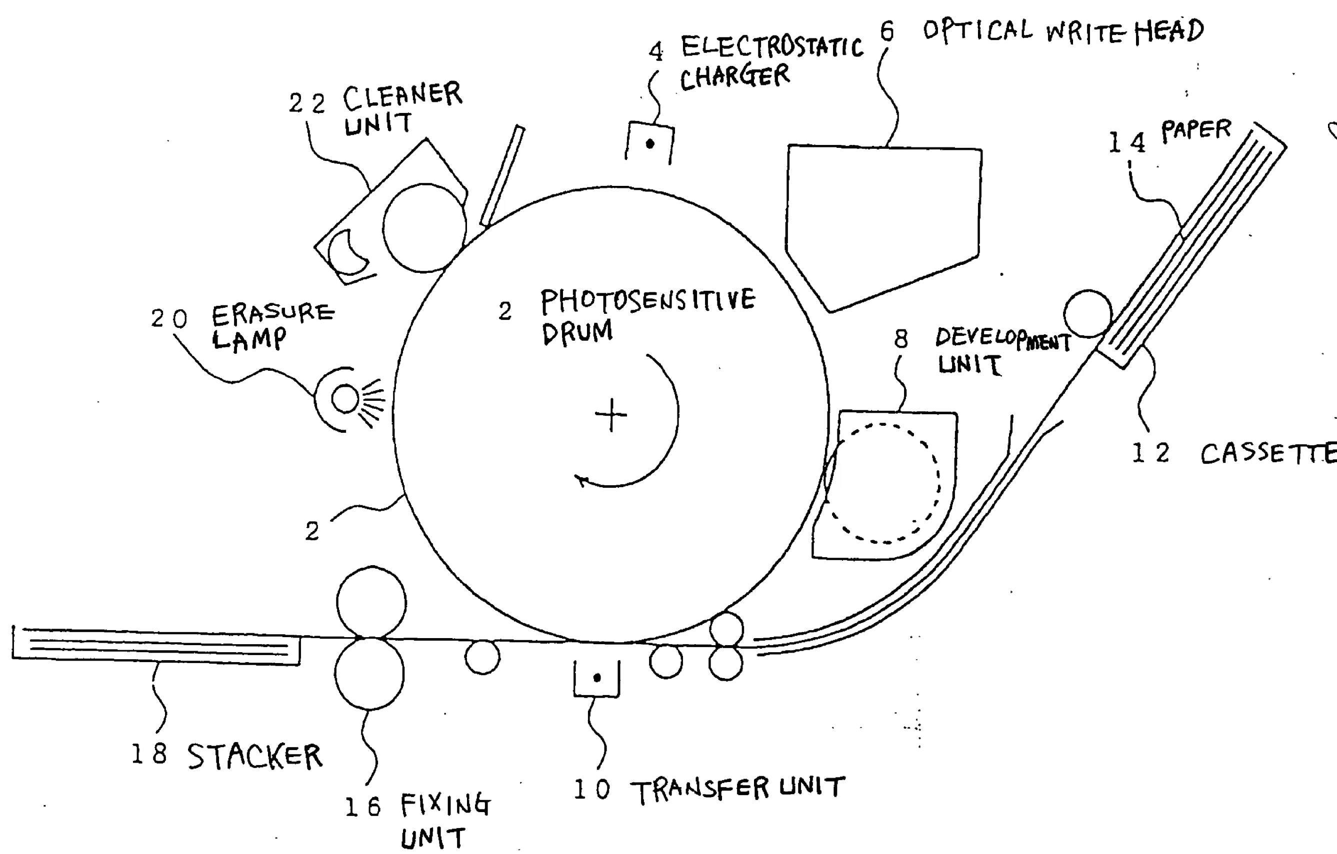
[Fig. 3]



[Fig. 4]

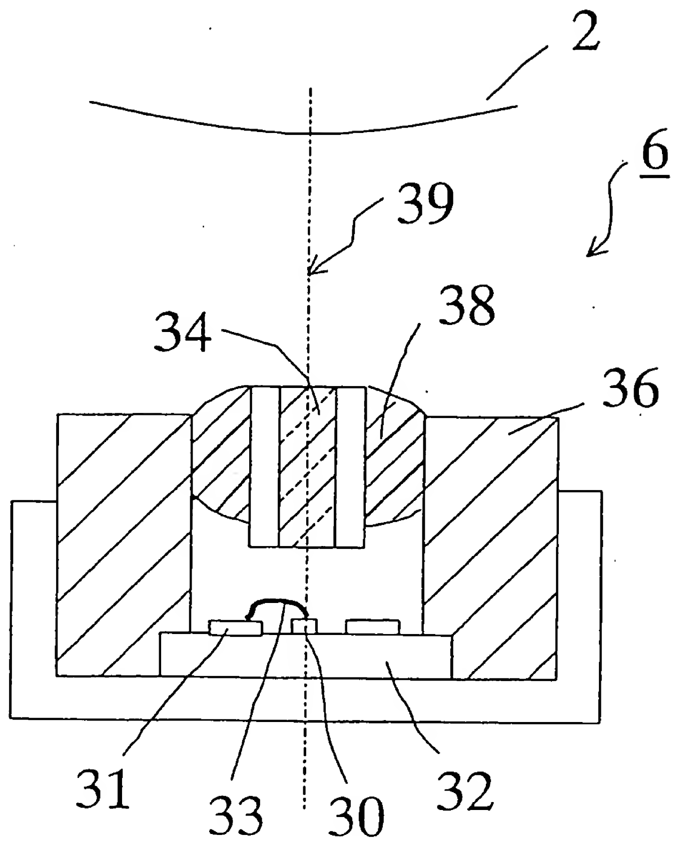


[Fig. 5]

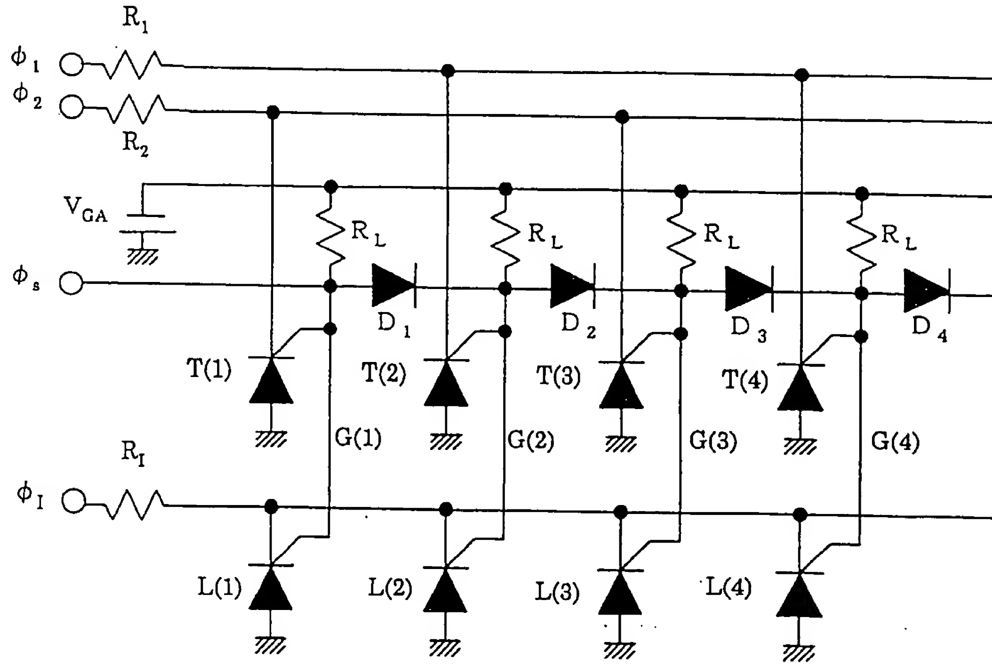


22 CLEANER UNIT
4 ELECTROSTATIC CHARGER
6 OPTICAL WRITE HEAD
14 PAPER
20 ERASURE LAMP
2 PHOTOSENSITIVE DRUM
8 DEVELOPMENT UNIT
12 CASSETTE
2
18 STACKER
16 FIXING UNIT
10 TRANSFER UNIT

[Fig. 6]



[Fig. 7]



ϕ_1
ϕ_2
R_1
R_2
V_{GA}
ϕ_s
R_L
D_1
D_2
D_3
D_4
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T(3)
T(4)
G(1)
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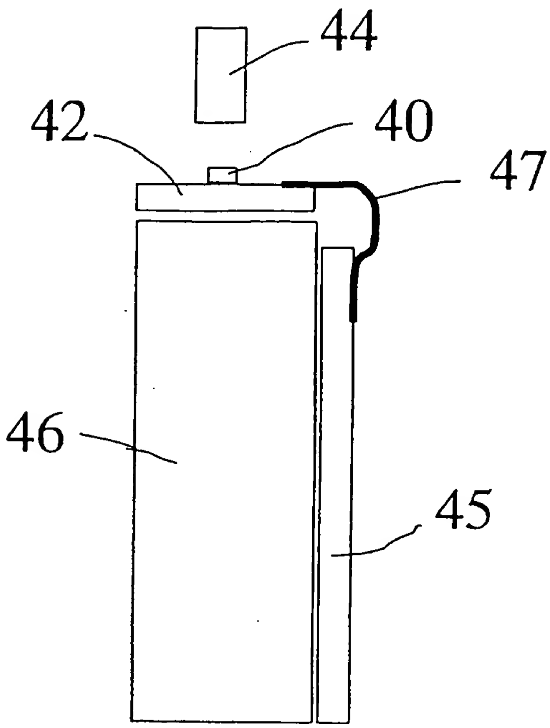
L(4)

[Fig. 8]



PATENT OFFICE
JAPANESE GOVERNMENT

This is to certify that the annexed is a true copy of the following application as filed with this office.

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Application Number: Patent Application No.2000-213006

Applicant(s): NIPPON SHEET GLASS CO., LTD.

May 25, 2001

Commissioner,
Patent Office

Kozo OIKAWA (Seal)

Issuance No. 2001-3043297

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[REFERENCE NUMBER] 00P203

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[DOCUMENT NAME] Abstract 1

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[REQUEST FOR PROOF] Yes

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[Document Name] Specification

[Title of the Invention] Optical Write Head

[Claims]

[Claim 1] An optical write head comprising a flexible circuit board remaining in close contact with a member having rigidity, and a plurality of light-emitting element array chips arranged on the flexible circuit board in a straight line or in a staggered layout so as to oppose a gradient index rod lens array, each of the light-emitting array chips having a light-emitting element array, wherein the member having rigidity is a metallic member substantially equal in coefficient of thermal expansion to the rod lens array.

[Claim 2] The optical write head according to claim 1, wherein a side plate of the rod lens array is formed from glass, and the metallic member is a nickel alloy or titanium.

[Claim 3] The optical write head according to claim 1 or 2, wherein the light-emitting element array is a self-scan-type light-emitting element array.

[Detailed Description of the Invention]

[Field of the Invention]

The present invention relates to an optical write head used, for instance, in an electrophotographic printer, using light-emitting element array chips.

[Related Art]

An optical write head to be used in an optical printer has hitherto been equipped with light-emitting element arrays, such as light-emitting diodes. The principle of an optical printer equipped with an optical write head (an optical printer head) is illustrated in Fig. 5. The surface of a cylindrical photosensitive drum 2 is coated with material (photosensitive material) possessing optical conductivity, such as amorphous Si or organic material. The photosensitive drum 2 rotates in accordance with a print speed. To begin with printing, the surface of photosensitive material provided over a rotating drum is charged uniformly with an electrostatic charger 4.

Next, an optical write head 6 radiates, onto the photosensitive material, light which assumes the image of a dot to be printed, thereby neutralizing the thus-exposed portion of the photosensitive material and forming a latent image. Subsequently, a development unit 8 causes toner to adhere to the photosensitive material in accordance with the charged status of the photosensitive material. A transfer unit 10 transfers toner onto paper 14 supplied from a cassette 12. A fixing unit 16 applies heat to the paper, thereby fixing the toner transferred on the paper. The paper is then fed to a stacker 18. After transfer of the latent image has been completed, the entirety of the electrically-charged photosensitive drum 2 is neutralized by an erasure lamp 20, and residual toner is removed by a cleaner unit 22.

As shown in a cross-sectional view of Fig. 6, in the optical write head 6, a plurality of light-emitting element array chips 30 are arranged in a single line on a printed circuit board 32 formed from glass epoxy, in accordance with specifications pertaining to a print width. A rod-lens array 34 having gradient index rod lenses stacked thereon in the form of one or two lines is arranged opposite the light-emitting element array chips 30. The light-emitting element array chips 30 and the rod lens arrays 34 are fixed on a housing 36 by means of a silicon filler 38.

A light-emitting diode (LED) array has usually been used widely as a light-emitting element array. Each of the LED elements involves variations in the amount of light emission. Further, each of rod lenses involves variations in optical characteristic. These variations account for inconsistencies in density of an image. If a currently-available LED array is used in its present form, variations in density will exceed the allowable density limit of the LED. For this reason, the amount of light is corrected such that inconsistencies in density of an image fall within the allowable density limit of an LED, by means of changing drive conditions for each of LEDs. The amount of light is usually corrected in accordance with the following procedures. While the optical write head is separated from the printer, LEDs are illuminated one by one, and a light-receiving element is situated at a position where an image is to be formed, thereby determining the distribution of light quantity over the head in its longitudinal

direction. The thus-determined distribution of light quantity is recorded. A per-chip drive current to be supplied to LEDs or the period of illumination of the respective chip of LEDs is determined from the recorded light quantity distribution such that the light quantity distribution is flattened. At the time of actual use of the light-emitting array, the thus-determined drive conditions are employed.

[Problems to be solved by the Invention]

However, in practice, an optical write head is used in the environment where ambient temperature changes. The positional precision of layout of light-emitting element array chips is influenced by thermal expansion of a glass epoxy substrate. Further, the positional precision of layout of a rod lens array is influenced by thermal expansion of glass-fiber-reinforced plastic (GFRP). Accordingly, there may be a case where the optical axis of a light-emitting array chip and the optical axis of a rod lens may deviate from an initially-adjusted position in the longitudinal direction of the print head. Inconsistencies in an image stemming from such deviation cannot be compensated by the electrical correction of light quantity set forth.

The present invention is aimed at solving the foregoing drawback, providing an optical write head having high reliability with respect to temperature variations, and realizing a high-resolution electrophotographic printer.

[Means for solving the problems]

There is provided an optical write head comprising a flexible circuit board remaining in close contact with a member having rigidity, and a plurality of light-emitting element array chips arranged on the flexible circuit board in a straight line or in a staggered layout so as to oppose a gradient index rod lens array, each of the light-emitting array chips having a light-emitting element array, wherein the member having rigidity is a metallic member substantially equal in coefficient of thermal expansion to the rod lens array. Preferably, a side plate of the rod lens array is formed from glass, and the metallic member is a nickel alloy or titanium. Further, in this arrangement, the light-emitting element array is preferably a self-scan-type light-emitting element array.

[Embodiment of the Invention]

An embodiment of the present invention will be described hereinbelow by reference to Figs. 1 through 3. Fig. 1 is a side view showing the side of an optical write head according to the present invention, the side being perpendicular to a primary scanning direction. Fig. 2 is a plan view showing a portion of the optical write head when viewed from top of a light-emitting element surface from which light exits. Fig. 3 is a cross-sectional view of a head major portion.

As shown in these drawings, a FPC substrate 57 of a two layer type is adhered to a metal block 51, and light-emitting array chips 50 are die-bonded thereto. Wirings on the FPC substrate

57 and light-emitting element electrode pads on the chips are connected by wire bond. Subsequently, the metal block 51 is attached to a support member 56 by means of, for example, a bolt 53. A rod lens array 54 is preliminarily adhered to a predetermined position of the metal block 51, and a light-emitting element array drive circuit board 55 is mounted thereto. The wirings of the FPC substrate 57 are connected by coupling a connector terminal 66 at the end to a connector 64 of the drive circuit board 55.

In an apparatus such as an electrophotographic printer, the ambient temperature of the optical write head rises from room temperature at startup of the printer to a temperature of about 65°C, as a result of heating of the optical write head and heating of individual components provided in the printer. Provided that room temperature is 25°C, temperature rises 40°C from room temperature at the startup of the printer.

A related-art glass epoxy substrate having light-emitting array chips mounted thereon has a coefficient of thermal expansion of 65 x 10^{-5} deg^{-1} or thereabouts. FRP (composite material consisting of a glass fiber mat and thermosetting resin) is used for the side plate of an ordinary rod lens array. The coefficient of thermal expansion of FRP involves variations unique to a composite material (i.e., 6×10^{-6} deg^{-1} to 16×10^{-6} deg^{-1}). Control of the variations is difficult.

In a case where a photosensitive drum requires an exposure

length of 320 mm (so as to comply with a size slightly larger than A3, the extent to which a substrate having light-emitting elements mounted thereon is to expand is 65 x 10^{-6} deg^{-1} x 40 deg. x 320 mm = 0.83 mm. The extent to which SLA is to expand is 6 x 10^{-6} deg^{-1} x 40 deg. x 320 mm = 0.077 to 0.20 mm. When the point on one end of the optical write head is taken as a reference position, a maximum difference in coefficient of thermal expansion arising between the substrate and the rod lens array in its lengthwise direction is 0.76 mm.

The diameter of a high-resolution rod lens is about 0.6 to 1 mm. The lens provided on the end opposite to the reference position is offset from the light-emitting elements by about one lens element. Per-lens variations in coupling efficiency of a lens and inconsistencies in light-quantum cycle induce changes in a corrected light-quantity value, which in turn induces inconsistencies in the amount of light.

Further, variations in coefficient of thermal expansion of the glass epoxy substrate stemming from heating of light-emitting elements elongate the width of an image appearing on a light-receiving surface by 0.8 mm.

In order to prevent deterioration in image quality, which would otherwise be induced by temperature variations, the following means is employed in the present invention.

Homogeneous material having a high degree of plane smoothness and a low coefficient of thermal expansion is desirable as material

for the side plate of the rod lens array. Soda lime glass, which is a low-cost material, has a coefficient of thermal expansion of about 8.8×10^{-6} deg^{-1} and matches the above-described requirements.

A conceivable measure to prevent variations in relative position between the light-emitting array chip and the lens element stemming from changes in temperature is to use material having a low coefficient of thermal expansion for the substrate and the rod lens array. Finding another material is difficult, in view of ease of working and costs. For this reason, there is employed a method of allowing given thermal expansion and taking the thermal expansion into account.

In connection with the structure of the related-art optical write head, variations in the position of the light-emitting elements due to temperature changes depend on the temperature characteristic of a substrate on which light-emitting elements are to be bonded, in the same manner as mentioned previously. For this reason, there must be selected a material whose coefficient of thermal expansion is close to that of a rod lens array having a glass side plate; that is, a thermal expansion coefficient of 8.8×10^{-6} deg^{-1}. As an insulating material for a substrate set forth, there can be employed ceramic, such as alumina, as provided in Table 1. However, a ceramic circuit board encounters difficulty in stacking patterns on the board, thus resulting in an increase in the area of the board. Further,

such an insulating material is comparatively expensive.

For this reason, the present invention provides an optical write head for solving these problems. Fig. 3 is a cross-sectional view showing the principal section of the optical write head according to the present invention. In an FPC substrate 57, copper foil wiring patterns 61 and 62 are laid on the surface of a resin layer 58 formed from high-temperature-resistant resin such as polyimide. The FPC substrate 57 is bonded to a metal block 251 formed from metallic material, by means of a thermosetting adhesive 65. Light-emitting element array chips 50 are arranged and mounted in predetermined positions on the FPC substrate 57 bonded onto the metal block 51. The light-emitting element array chips 50 are arranged by means of a die bonder and fixed by means of a conductive adhesive. Before assembly of the FPC substrate 57 into an optical write head, the light-emitting array chips 50 and the FPC substrate 57 are electrically connected together through use of Au lines 63, by means of wire bonding.

As shown in Fig. 1, the metal block 51 is secured onto a support member 56 having rigidity, by means such as a bolt 53. The rod lens array 54 is bonded to a predetermined position on the support member 56. The drive circuit board 55 is also secured to the support member 56. The other end of the FPC substrate 57 is connected to a connector 64 provided on the drive circuit board 55.

Since the FPC substrate 57 is formed from resin such as

polyimide, the resin by nature possesses a very high coefficient of thermal expansion, as provided in Table 1. However, the resin is a thin and flexible material. The extent to which resin is to thermally expand is substantially determined by the extent to which the material bonded to the metal block 51 is to thermally expand. Accordingly, the only requirement is that a material which is to thermally expand to the same extent as the rod lens array 54 be selected as material for the metal block 51.

When 42% nickel steel having a thermal expansion coefficient of 8.1×10^{-6} deg^{-1} is employed as material for the metal block 51, the extent to which the light-emitting element array chips 50 are to thermally expand is 8.1×10^{-6} $deg^{-1} \times 40$ deg $\times$ 320 mm = 0.10 mm for a size slightly larger than A3. The extent to which the optical write head according to the present invention is to thermally expand can be made 0.73 mm smaller than that to which a related-art optical write head formed from a glass epoxy substrate is to thermally expand. The percentage of change in the width of an image due to a temperature change (e.g., a change from 25°C to 65°C) can be reduced from 0.26% to 0.03%.

Moreover, as shown in Table 1, Ti has a thermal expansion coefficient of about 7×10^{-5} deg^{-1}, and this material can also be used for the metal block 51.

The amount of light is usually corrected while the optical write head is separated from a printer. A light-receiving element is situated at a position where an image is to be formed, and

the distribution of light quantity is determined. In order to make the distribution of light quantity flat, the amount of light is controlled by means of changing a per-chip current to be supplied to the light-emitting elements. At this time, there is a necessity of setting ambient temperature to the temperature of the surroundings of the optical write head arising during operation of the printer, thereby enabling effective correction of the distribution of light quantity during actual operation of the printer. However, the present invention obviates a necessity of temperature setting. Even if changes arise in the temperature of the optical write head during operation, correction of light quantity remains effective.

Since the glass epoxy substrate is material which is less likely to conduct heat (having a thermal conductivity of 0.38 W/m·k), the amount of heat liberated from the optical write head is low, and hence a rise in the temperature of the light-emitting array chips becomes greater. The amount of light emitted by a GaAs-based light-emitting element is known to drop about 0.5% as the temperature of the light-emitting element chip rises by 1°C. Hence, a rise in the temperature of the light-emitting array chip accounts for a drop in the amount of light, with the result that a print speed is decreased. Further, if the substrate dissipates less heat than light-emitting array chip, a difference in the temperature distribution of the light-emitting element array chips 50 in its lengthwise direction is increased, thus

resulting in an increase in unevenness in the amount of light in the secondary scanning direction.

As shown in Fig. 3, in the structure of the optical write head according to the present invention, only the resin (polyimide) layer 58 of 25 μm thickness and the copper foil 62 of 18 μm are interposed between the light-emitting array chips 50 and the metal block 51. The heat developing in the light-emitting element array chips 50 is readily propagated to the metal block 51 serving as a heat sink. Hence, a difference in the heat distribution of the light-emitting element array chips 50 and a rise in the temperatures of all the light-emitting element array chips 50 can be reduced. Preferably, the FPC substrate 57 can be made as thin as possible.

According to thermal analysis data, a difference in temperature distribution of a glass epoxy substrate structure is estimated as 0.041°C, and that of a flexible printed wiring board structure of the same geometry is estimated as 0.08°C. Use of the flexible printed wiring board results in a temperature rise being dropped from 16°C to 6°C.

A related-art LED array can be applied to a light-emitting element array to be used in the optical write head according to the present invention. Use of a self-scan-type light-emitting element array is more preferable. The reason for this is that the self-scan-type light-emitting element array obviates a

necessity of interconnecting a light-emitting element and a driver IC in a one-to-one relationship. The self-scan-type light-emitting element array is suitable for a case where a substrate having a light-emitting element array mounted thereon is separated from a substrate having driver ICs mounted thereon.

Fig. 4 shows an equivalent circuit diagram of the self-scan-type light-emitting array (as described in Japanese Patent Application Laid-Open No. 263668/1990). The light-emitting device is formed from an array consisting of transfer thyristor elements T(1), T(2), … and light-emitting thyristor elements L(1), L(2), … The drawing shows only a portion of the array. The transfer thyristor elements T(1), T(2), … are interconnected by means of diodes D1, D2, … V_{GA} denotes a power line (usually assuming -5V) which is connected to a gate electrode of each of the thyristor elements T and L. A start pulse signal ϕ_s is applied to the gate electrode of the thyristor element T(1). Clock pulse signals ϕ_1 and ϕ_2 are applied to the cathode electrodes of alternating thyristor elements T. The gate electrodes of the transfer thyristor elements T(1), T(2), … and the corresponding gate electrodes of the light-emitting thyristor elements are interconnected by means of wires G(1), G(2), … A write signal ϕ_I is applied also to the cathode electrodes of the light-emitting thyristor elements L.

In the above-described circuit configuration, the thyristor

elements T(1), T(2), … are sequentially turned on by means of the two clock pulse signals ϕ_1 and ϕ_2. In association with such turning-on action, the light-emitting thyristors L(1), L(2), … enter a state in which they can be turned on sequentially. If any one of light-emitting thyristor elements is turned on or enters a luminous state, the luminous intensity of the light-emitting thyristor element is determined by the amount of electric current to flow as a write signal ϕ_I; that is, resistance R_I. An image can be written at arbitrary intensity. As can be seen from Fig. 5, the self-scan-type light-emitting array of such a configuration requires interconnection of only a total of six terminals per chip; that is, two power terminals and four signal terminals. Thus, the number of connections does not depend on the number of light-emitting elements mounted on one chip. Hence, in a case where 128 light-emitting elements, for example, are mounted per chip, the number of wires to be connected to a drive IC per chip can be reduced to one-twentieth those required for a related-art LED array chip.

By replacing a related-art LED array chip with the self-scan-type light-emitting array chip, a driver IC can be readily mounted on a substrate differing from that having light-emitting elements mounted thereon (see Japanese Patent Application Laid-Open No. 187981/1997). Such a construction can be said to be a method for reducing the width of the substrates and miniaturizing an optical write head more effectively than

a method using the related-art LED array chip.

TABLE 1

MATERIAL	THERMAL CONDUCTIVITY (W/m·K)	COEFFICIENT OF THERMAL EXPANSION (10^{-6} deg^{-1})
GLASS	0.76	8.8
Cu	339	16.5
Ti	27	7.0
Ni ALLOY	13.4	8.1
POLYIMIDE	0.1	170
FRP	-	6 THROUGH 16
GaAs	-	6.0

[Effect of the Invention]

According to the present embodiment, there can be prevented a misalignment between the optical axis of an optical write head and the optical axis of a light-emitting element, which would otherwise be caused by temperature variations arising during assembly or operation of the optical write head. Accordingly, occurrence of inconsistencies in the density of an image can be prevented. There is also obviated a necessity for managing the temperature of the optical write head when the distribution of light quantity is measured for correcting light quantity. Further, dissipation of heat from the light-emitting elements

is improved. Hence, variations in the distribution of light quantity of light-emitting array chips due to temperature variations can be reduced. There can be prevented occurrence of inconsistencies in density of an image, which would otherwise be caused by variations in the distribution of light quantity.

[Brief Description of the Drawings]

Fig. 1 is a side view of an optical write head according to the present invention;

Fig. 2 is a plan view showing a portion of the optical write head according to the present invention having light-emitting element array chips mounted thereon;

Fig. 3 is a cross-sectional view showing the principal section of the optical write head according to the present invention;

Fig. 4 is an equivalent circuit diagram showing a self-scan-type light-emitting element array;

Fig. 5 is a schematic view showing the principle of an optical printer equipped with an optical write head;

Fig. 6 is a schematic cross-sectional view showing the construction of a related-art optical printer head.

[Description of Reference Numerals]

2 photosensitive drum

6 optical write head

30,50 light-emitting element array chip

31 driver IC chip

32,42 substrate

33,63 Au line

34,54 rod lens array

51 metal block

55 drive circuit board

56 support member

57 flexible printed circuit substrate

58 resin layer

61,62 copper-foil wiring pattern

65 thermosetting adhesive

[Document Name] Abstract

[Abstract]

[Object]

There may be a case where the optical axis of a light-emitting array chip and the optical axis of a rod lens may deviate from an initially-adjusted position in an optical write head due to temperature variation. Inconsistencies in an image stemming from such deviation cannot be compensated by the electrical correction of light quantity.

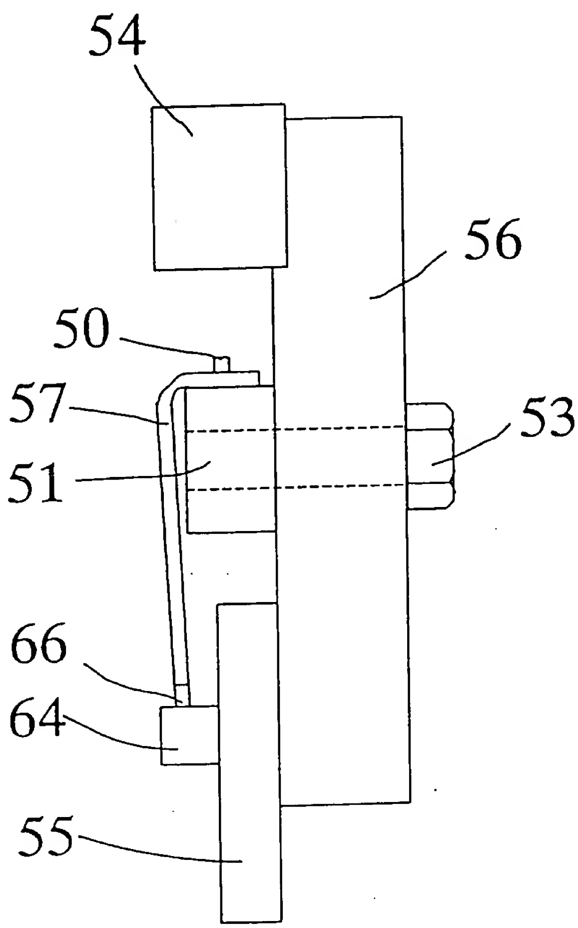
[Solution]

An optical write head comprising a flexible circuit board 57 remaining in close contact with a metal block 51, and a plurality of light-emitting element array chips 50 arranged on the flexible circuit board in a straight line or in a staggered layout so as to oppose a gradient index rod lens array 54, each of the light-emitting array chips 50 having a light-emitting element array, wherein the metal block 51 is a metallic member substantially equal in coefficient of thermal expansion to the rod lens array 54 and the light-emitting element array chips 50. Preferably, a side plate of the rod lens array 54 is formed from glass, and the metallic member is a nickel alloy or titanium. Further, in this arrangement, the light-emitting element array is preferably a self-scan-type light-emitting element array.

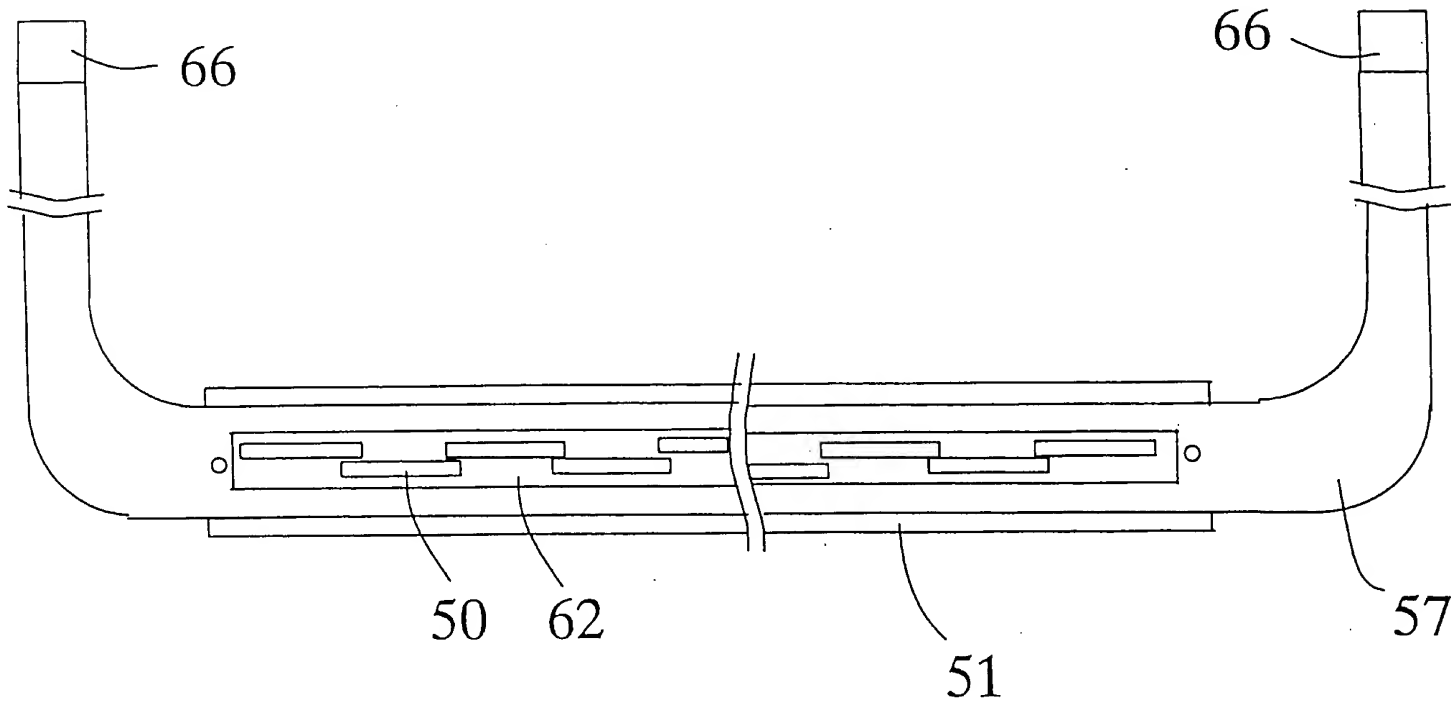
[Selected Drawing] Fig. 1

[Name of Document] Drawings

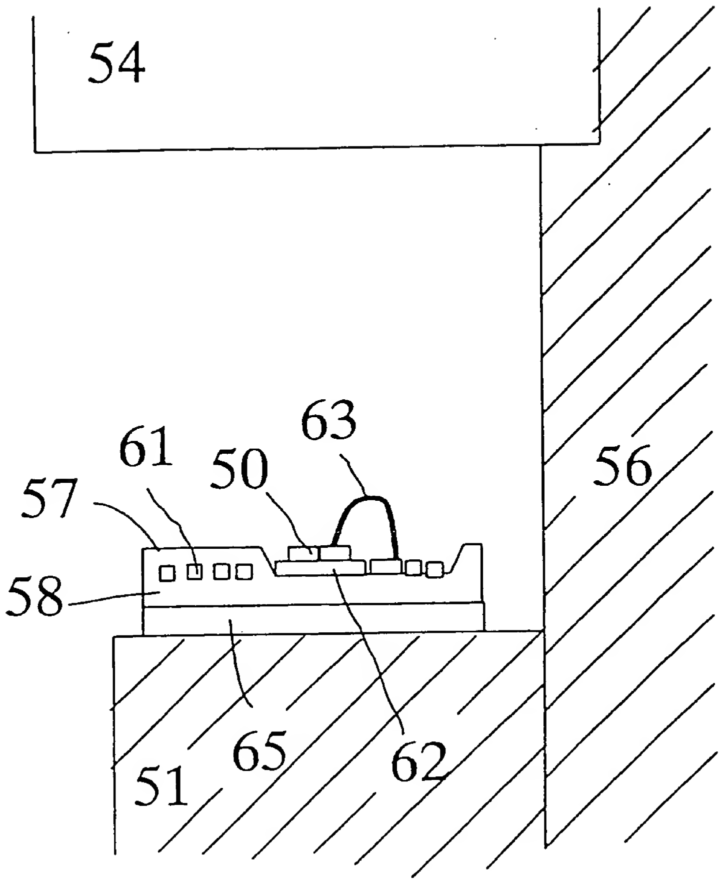
[Fig.1]



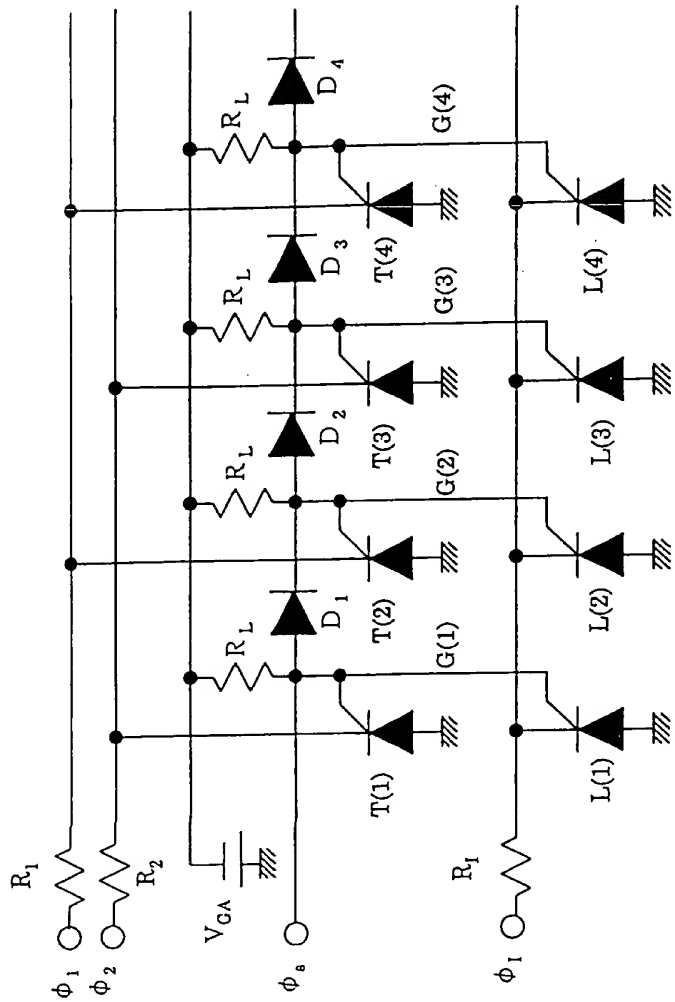
[Fig.2]



[Fig.3]



[Fig.4]



φ1
φ2
R1
R2
VGA
φs
RI
φI
RL
D1
D2
D3
D4
G(1)
G(2)
G(3)
G(4)
T(1)
T(2)
T(3)
T(4)
L(1)
L(2)
L(3)
L(4)

[Fig 5]

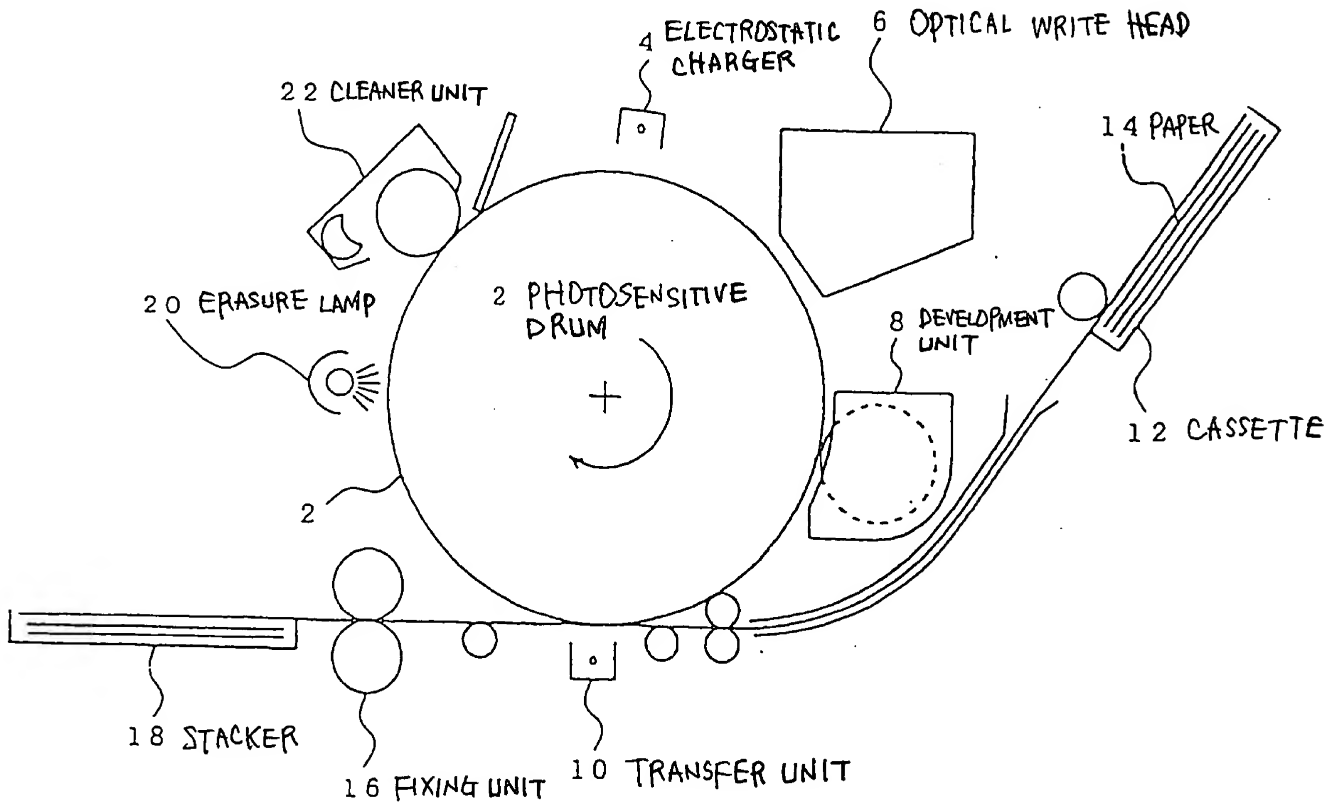

4 ELECTROSTATIC CHARGER
6 OPTICAL WRITE HEAD
22 CLEANER UNIT
14 PAPER
20 ERASURE LAMP
2 PHOTOSENSITIVE DRUM
8 DEVELOPMENT UNIT
12 CASSETTE
2
18 STACKER
16 FIXING UNIT
10 TRANSFER UNIT

Fig. 6